ENCYCLOPÆDIA BRITANNICA

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DISSERTATION FIRST:

EXHIBITING A GENERAL VIEW

OF THE

PROGRESS OF METAPHYSICAL AND ETHICAL PHILOSOPHY,

SINCE THE REVIVAL OF LETTERS IN EUROPE.

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PREFACE,

CONTAINING SOME CRITICAL REMARKS ON THE DISCOURSE PREFIXED TO THE FRENCH ENCYCLOPÉDIE.

WHEN I ventured to undertake the task of contributing a Preliminary Dissertation to the *Encyclopædia Britannica*, my original intention was, after the example of D'Alembert, to have begun with a general survey of the various departments of human knowledge. The outline of such a survey, sketched by the comprehensive genius of Bacon, together with the corrections and improvements suggested by his illustrious disciple, would, I thought, have rendered it comparatively easy to adapt their intellectual map to the present advanced state of the sciences; while the unrivalled authority which their united work has long maintained in the republic of letters, would, I flattered myself, have softened those criticisms which might be expected to be incurred by any similar attempt of a more modern hand. On a closer examination, however, of their labours, I found myself under the necessity of abandoning this design. Doubts immediately occurred to me with respect to the justness of their logical views, and soon terminated in a conviction that these views are radically and essentially erroneous. Instead, therefore, of endeavouring to give additional currency to speculations which I conceived to be fundamentally unsound, I resolved to avail myself of the present opportunity to point out their most important defects;—defects which, I am nevertheless very ready to acknowledge, it is much more easy to remark than to supply. The critical strictures which, in the course of this discussion, I shall have occasion to offer on my predecessors, will, at the same time, account for my forbearing to substitute a new map of my own, instead of that to which the names of Bacon and D'Alembert have lent so great and so well-merited a celebrity; and may perhaps suggest a doubt, whether the period be yet arrived for hazarding again, with any reasonable prospect of success, a repetition of their bold experiment. For the length to which these strictures are likely to extend, the only apology I have to offer is the peculiar importance of the questions to which they relate, and the high authority of the writers whose opinions I presume to controvert.

Before entering on his main subject, D'Alembert is at pains to explain a distinction—which he represents as of considerable importance—between the Genealogy of the sciences, and the Encyclopedical arrangement of the objects of human knowledge.[1] "In examining the former," he observes, "our aim is, by remounting to the origin and genesis of our ideas, to trace the causes to which the sciences owe their birth; and to mark the characteristics by which they are distinguished from each other. In order to ascertain the latter, it is necessary to comprehend, in one general *scheme*, all the various departments of study; to arrange them into proper classes; and to point out their mutual relations and dependencies." Such a *scheme* is sometimes likened by D'Alembert to a map or chart of the intellectual world; sometimes to a Genealogical[1] or Encyclopedical Tree, indicating the manifold and complicated affinities of those studies, which, however apparently remote and unconnected, are all the common offspring of the human understanding. For executing successfully this chart or tree, a philosophical delineation of the natural progress of the mind may (according to him) furnish very useful lights; although he acknowledges that the results of the two undertakings cannot fail to differ widely in many instances,—the laws which regulate the generation of our ideas often interfering with that systematical order in the relative arrangement of scientific pursuits, which it is the purpose of the Encyclopedical Tree to exhibit.[2]

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[1] "Il ne faut pas confondre l'ordre Encyclopédique des connoissances humaines avec la Génealogie des Sciences." Avertissement, p. 7.

In treating of the first of these subjects, it cannot be denied that D'Alembert has displayed much ingenuity and invention; but the depth and solidity of his general train of thought may be questioned. On various occasions, he has evidently suffered himself to be misled by a spirit of false refinement; and on others, where probably he was fully aware of his inability to render the theoretical chain complete, he seems to have aimed at concealing from his readers the faulty links, by availing himself of those epigrammatic points, and other artifices of style, with which the genius of the French language enables a skilful writer to smooth and varnish over his most illogical transitions.

The most essential imperfections, however, of this historical sketch, may be fairly ascribed to a certain vagueness and indecision in the author's idea, with regard to the scope of his inquiries. What he has in general pointed at is to trace, from the theory of the Mind, and from the order followed by nature in the developement of its powers, the successive steps by which the curiosity may be conceived to have been gradually conducted from one intellectual pursuit to another; but, in the execution of this design (which in itself is highly philosophical and interesting), he does not appear to have paid due attention to the essential difference between the history of the human species, and that of the civilised and inquisitive individual. The former was undoubtedly that which principally figured in his conceptions, and to which, I apprehend, he ought to have confined himself exclusively; whereas, in fact, he has so completely blended the two subjects together, that it is often impossible to say which of them was uppermost in his thoughts. The consequence is, that, instead of throwing upon either those strong and steady lights, which might have been expected from his powers, he has involved both in additional obscurity. This indistinctness is more peculiarly remarkable in the beginning of his Discourse, where he represents men in the earliest infancy of science, before they had time to take any precautions for securing the means of their subsistence, or of their safety,—as philosophising on their sensations, on the existence of their own bodies, and on that of the material world. His Discourse, accordingly, sets out with a series of Meditations, precisely analogous to those which form the introduction to the philosophy of Descartes; meditations which, in the order of time, have been uniformly posterior to the study of external nature; and which, even in such an age as the present, are confined to a comparatively small number of recluse metaphysicians.

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[1] It is to be regretted, that the epithet *Genealogical* should have been employed on this occasion, where the author's wish was to contradistinguish the idea denoted by it, from that historical view of the sciences to which the word *Genealogy* had been previously applied.

[2] The true reason of this might perhaps have been assigned in simpler terms by remarking, that the order of invention is, in most cases, the reverse of that fitted for didactic communication. This observation applies not only to the analytical and synthetical processes of the *individual*, but to the progressive improvements of the *species*, when compared with the arrangements prescribed by logical method, for conveying a knowledge of them to students. In an enlightened age, the sciences are justly considered as the basis of the arts; and, in a course of liberal education, the former are always taught prior to the latter. But, in the order of invention and discovery, the arts preceded the sciences. Men measured land before they studied speculative geometry; and governments were established before politics were studied as a science. A remark somewhat similar is made by Celsus, concerning the history of medicine: "Non medicinam rationi esse posteriorem, sed post medicinam inventam, rationem esse quæsitam."

Of this sort of *conjectural* or *theoretical* history, the most unexceptionable specimens which have yet appeared, are indisputably the fragments in Mr Smith's posthumous work on the History of Astronomy, and on that of the Ancient Systems of Physics and Metaphysics. That, in the latter of these, he may have occasionally accommodated his details to his own peculiar opinions concerning the object of Philosophy, may perhaps, with some truth, be alleged; but he must at least be allowed the merit of completely avoiding the error by which D'Alembert was misled; and, even in those instances where he himself seems to wander a little from the right path, of furnishing his successors with a thread, leading by easy and almost insensible steps, from the first gross perceptions of sense, to the most abstract refinements of the Grecian schools. Nor is this the only praise to which these fragments are entitled. By seizing on the different points of view from which the same object was contemplated by different sects, they often bestow a certain degree of unity and of interest on what before seemed calculated merely to bewilder and to confound; and render the apparent aberrations and caprices of the understanding, subservient to the study of its operations and laws.

To the foregoing strictures on D'Alembert's view of the origin of the sciences, it may be added, that this introductory part of his Discourse does not seem to have any immediate connection with the sequel. We are led, indeed, to expect, that it is to prepare the way for the study of the Encyclopedical Tree afterwards to be exhibited; but in this expectation we are completely disappointed,—no reference to it whatever being made by the author in the farther prosecution of his subject. It forms, accordingly, a portion of his Discourse altogether foreign to the general design; while, from the metaphysical obscurity which pervades it, the generality of readers are likely to receive an impression, either unfavourable to the perspicuity of the writer, or to their own powers of comprehension and of reasoning. It were to be wished, therefore, that, instead of occupying the first pages of the *Encyclopédie*, it had been reserved for a separate article in the body of that work. There it might have been read by the logical student, with no small interest and advantage; for, with all its imperfections, it bears numerous and precious marks of its author's hand.

In delineating his Encyclopedical Tree, D'Alembert has, in my opinion, been still more unsuccessful than in the speculations which have been hitherto under our review. His veneration for Bacon seems, on this occasion, to have prevented him from giving due scope to his own powerful and fertile genius, and has engaged him in the fruitless task of attempting, by means of arbitrary definitions, to draw a veil over incurable defects and blemishes. In this part of Bacon's logic, it must, at the same time, be owned, that there is something peculiarly captivating to the fancy; and, accordingly, it has united in its favour the suffrages of almost all the succeeding authors who have treated of the same subject. It will be necessary for me, therefore, to explain fully the grounds of that censure, which, in opposition to so many illustrious names, I have presumed to bestow on it.

Of the leading ideas to which I more particularly object, the following statement is given by D'Alembert. I quote it in preference to the corresponding passage in Bacon, as it contains various explanatory clauses and glosses, for which we are indebted to the ingenuity of the commentator.

"The objects about which our minds are occupied, are either spiritual or material, and the media employed for this purpose are our ideas, either directly received, or derived from reflection. The system of our direct knowledge consists entirely in the passive and mechanical accumulation of the particulars it comprehends; an accumulation which belongs exclusively to the province of Memory. Reflection is of two kinds, according as it is employed in reasoning on the objects of our direct ideas, or in studying them as models for imitation.

" Thus, Memory, Reason, strictly so called, and Imagination, are the three modes in which the mind operates on the subjects of its thoughts. By Imagination, however, is here to be understood, not the faculty of conceiving or representing to ourselves what we have formerly perceived, a faculty which differs in nothing from the memory of these perceptions, and which, if it were not relieved by the invention of signs, would be in a state of continual exercise. The power which we denote by this name has a nobler province allotted to it, that of rendering imitation subservient to the creations of genius.

" These three faculties suggest a corresponding division of human knowledge into three branches, 1. History, which derives its materials from Memory; 2. Philosophy, which is the product of Reason; and 3. Poetry (comprehending under this title all the Fine Arts), which is the offspring of Imagination.[1] If we place Reason before Imagination, it is because this order appears to us conformable to the natural progress of our intellectual operations.[2] The Imagination is a creative faculty; and the mind, before it attempts to create, begins by reasoning upon what it sees and knows. Nor is this all. In the faculty of Imagination, both Reason and Memory are, to a certain extent, combined,—the mind never imagining or creating objects but such as are analogous to those whereof it has had previous experience. Where this analogy is wanting, the combinations are extravagant and displeasing; and consequently, in that agreeable imitation of nature, at which the fine arts aim in common, invention is necessarily subjected to the control of rules which it is the business of the philosopher to investigate.

" In farther justification of this arrangement, it may be remarked, that reason, in the course of its successive operations on the subjects of thought, by creating abstract and general ideas, remote from the perceptions of sense, leads to the exercise of Imagination as the last step of the process. Thus metaphysics and geometry are, of all the sciences belonging to Reason, those in which Imagination has the greatest share. I ask pardon for this observation from those men of taste, who, little aware of the near affinity of geometry to their own pursuits, and still less suspecting that the only intermediate step between them is formed by metaphysics, are disposed to employ their wit in depreciating its value. The truth is, that, to the geometer who invents, Imagination is not less essential than to the poet who creates. They operate, indeed, differently on their object, the former abstracting and analyzing, where the latter combines and adorns;—two processes of the mind, it must at the same time be confessed, which seem from experience to be so little congenial, that it may be doubted if the talents of a great geometer and of a great poet will ever be united in the same person. But whether these talents be or be not mutually exclusive, certain it is, that they who possess the one, have no right to despise those who cultivate the other. Of all the great men of antiquity, Archimedes is perhaps he who is the best entitled to be placed by the side of Homer."

D'Alembert afterwards proceeds to observe, that of these three general branches of the Encyclopedical Tree, a natural and convenient subdivision is afforded by the metaphysical distribution of things into Material and Spiritual. " With these two classes of existences," he observes farther, " history and philosophy are equally conversant; but *as for Imagination, her imitations are entirely confined to the material world*;—a circumstance," he adds, " which conspires with the other arguments above stated, in justifying Bacon for assigning to her the *last* place in his enumeration of our intellectual faculties."[1] Upon this subdivision he enlarges at some length, and with considerable ingenuity; but on the present occasion it would be quite superfluous to follow him any farther, as more than enough has been already quoted to enable my readers to judge, whether the objections which I am now to state to the foregoing extracts be as sound and decisive as I apprehend them to be.

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[1] The latitude given by D'Alembert to the meaning of the word *Poetry* is a real and very important improvement on Bacon, who restricts it to Fictitious History or Fables. (*De Aug. Scient.* Lib. ii. cap. i.) D'Alembert, on the other hand, employs it in its natural signification, as synonymous with *invention* or *creation*. " La Peinture, la Sculpture, l'Architecture, la Poésie, la Musique, et leurs différentes divisions, composent la troisième distribution générale qui nait de l'Imagination, et dont les parties sont comprises sous le nom de Beaux-Arts. On peut les rapporter tous à la Poésie, en prenant ce mot dans sa signification naturelle, qui n'est autre chose qu'invention ou création."

[2] In placing Reason before Imagination, D'Alembert departs from the order in which these faculties are arranged by Bacon. " Si nous n'avons pas placé, comme lui, la Raison après l'Imagination, c'est que nous avons suivi dans le système Encyclopédique, l'ordre metaphysique des opérations de l'esprit, plutôt que l'ordre historique de ses progrès depuis la renaissance des lettres.—*(Disc. Prélim.)* How far the motive here assigned for the change is valid, the reader will be enabled to judge from the sequel of the above quotation.

Of these objections a very obvious one is suggested by a consideration, of which D'Alembert himself has taken notice,—that the three faculties to which he refers the whole operations of the understanding are perpetually blended together in their actual exercise, insomuch that there is scarcely a branch of human knowledge which does not, in a greater or less degree, furnish employment to them all. It may be said, indeed, that some pursuits exercise and invigorate particular faculties *more* than others; that the study of History, for example, although it may occasionally require the aid both of Reason and of Imagination, yet chiefly furnishes occupation to the Memory; and that this is sufficient to justify the logical division of our mental powers as the ground-work of a corresponding Encyclopedical classification.[2] This, however, will be found more specious than solid. In what respects is the faculty of Memory more essentially necessary to the student of history than to the philosopher or to the poet; and, on the other hand, of what value, in the circle of the sciences, would be a collection of historical details, accumulated without discrimination, without a scrupulous examination of evidence, or without any attempt to compare and to generalize? For the cultivation of that species of history, in particular, which alone deserves a place in the Encyclopedical Tree, it may be justly affirmed, that the rarest and most comprehensive combination of all our mental gifts is indispensably requisite.

Another, and a still more formidable objection to Bacon's classification, may be derived from the very imperfect and partial analysis of the mind which it assumes as its basis. Why were the powers of Abstraction and Generalization passed over in silence?—powers which, according as they are cultivated or neglected, constitute the most essential of all distinctions between the intellectual characters of individuals. A corresponding distinction, too, not less important, may be remarked among the objects of human study, according as our aim is to treasure up particular facts, or to establish general conclusions. Does not this distinction mark out, with greater precision, the limits which separate philosophy from mere historical narrative, than that which turns upon the different provinces of Reason and of Memory?

I shall only add one other criticism on this celebrated enumeration, and that is, its want of distinctness, in confounding together the Sciences and the Arts under the same general titles. Hence a variety of those capricious arrangements, which must immediately strike every reader who follows Bacon through his details;—the reference, for instance, of the mechanical arts to the department of History; and consequently, according to his own analysis of the Mind, the ultimate reference of these arts to the faculty of Memory; while at the same time, in his tripartite division of the whole field of human knowledge, the art of Poetry has one entire province allotted to itself.

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[1] In this exclusive limitation of the province of Imagination to things Material and Sensible, D'Alembert has followed the definition given by Descartes in his second Meditation: "*Imaginari nihil aliud est quam rei corporeæ figuram seu imaginem contemplari*;"—a power of the mind, which (as I have elsewhere observed) appears to me to be most precisely expressed in our language by the word *Conception*. The province assigned to Imagination by D'Alembert is more extensive than this, for he ascribes to her also a creative and combining power; but still his definition agrees with that of Descartes, inasmuch as it excludes entirely from her dominion both the intellectual and the moral worlds.

[2] I allude here to the following apology for Bacon, suggested by a very learned and judicious writer:—" On a fait cependant à Bacon quelques reproches assez fondés. On a observé que sa classification des sciences repose sur une distinction qui n'est pas rigoureuse, puisque la mémoire, la raison, et l'imagination concourent nécessairement dans chaque art, comme dans chaque science. Mais on peut répondre, que l'un ou l'autre de ces trois facultés, quoique secondée par les deux autres, peut cependant jouer le rôle principal. En prenant la distinction de Bacon dans ce sens, sa classification reste exacte, et devient très utile."—(DEGERANDO, *Hist. Comp.* Tome I. p. 298.)

These objections apply in common to Bacon and to D'Alembert. That which follows has a particular reference to a passage already cited from the latter, where, by some false refinements concerning the nature and functions of Imagination, he has rendered the classification of his predecessor incomparably more indistinct and illogical than it seemed to be before.

That all the creations or new combinations of Imagination, imply the previous process of decomposition or analysis, is abundantly manifest; and, therefore, without departing from the common and popular use of language, it may undoubtedly be said, that the faculty of abstraction is not less essential to the Poet, than to the Geometer and the Metaphysician.[1] But this is not the doctrine of D'Alembert. On the contrary, he affirms, that Metaphysics and Geometry are, of all the sciences connected with reason, those in which Imagination has the greatest share;—an assertion which, it will not be disputed, has at first sight somewhat of the air of a paradox; and which, on closer examination, will, I apprehend, be found altogether inconsistent with fact. If indeed D'Alembert had, in this instance, used, as some writers have done, the word Imagination as synonymous with Invention, I should not have thought it worth while (at least so far as the geometer is concerned) to dispute his proposition. But that this was not the meaning annexed to it by the author, appears from a subsequent clause, where he tells us, that the most refined operations of reason, consisting in the creation of *generals* which do not fall under the cognizance of our senses, naturally led to the exercise of Imagination. His doctrine, therefore, goes to the identification of Imagination with Abstraction: two faculties so very different in the direction which they give to our thoughts, that, according to his own acknowledgment, the man who is habitually occupied in exerting the one, seldom fails to impair both his capacity and his relish for the exercise of the other.

This identification of two faculties, so strongly contrasted in their characteristical features, was least of all to be expected from a logician, who had previously limited the province of Imagination to the imitation of material objects; a limitation, it may be remarked in passing, which is neither sanctioned by common use, nor by just views of the philosophy of the mind. Upon what ground can it be alleged, that Milton's portrait of Satan's intellectual and moral character was not the offspring of the same creative faculty which gave birth to his Garden of Eden? After such a definition, however, it is difficult to conceive, how so very acute a writer should have referred to Imagination the abstractions of the geometer and of the metaphysician; and still more, that he should have attempted to justify this reference, by observing, that these abstractions do not fall under the cognisance of the senses. My own opinion is, that, in the composition of the whole passage, he had a view to the unexpected parallel between Homer and Archimedes, with which he meant, at the close, to surprise his readers.

If the foregoing strictures be well-founded, it seems to follow, not only that the attempt of Bacon and of D'Alembert to classify the sciences and arts according to a logical division of our faculties, is altogether unsatisfactory; but that every future attempt of the same kind may be expected to be liable to similar objections. In studying, indeed, the Theory of the Mind, it is necessary to push our analysis as far as the nature of the subject admits of; and, wherever the thing is possible, to examine its constituent principles separately and apart from each other: but this consideration itself, when combined with what was before stated on the endless variety of forms in which they may be blended together in our various intellectual pursuits, is sufficient to show how ill adapted such an analysis must for ever remain to serve as the basis of an Encyclopedical distribution.[1]

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[1] This assertion must, however, be understood with some qualifications; for, although the Poet, as well as the Geometer and the Metaphysician, be perpetually called upon to decompose, by means of abstraction, the complicated objects of perception, it must not be concluded that the abstractions of all the three are exactly of the same kind. Those of the Poet amount to nothing more than to a separation into parts of the realities presented to his senses; which separation is only a preliminary step to a subsequent recomposition into new and ideal forms of the things abstracted; whereas the abstractions of the Metaphysician and of the Geometer form the very objects of their respective sciences.

The circumstance to which this part of Bacon's philosophy is chiefly indebted for its popularity, is the specious simplicity and comprehensiveness of the distribution itself;—not the soundness of the logical views by which it was suggested. That all our intellectual pursuits may be referred to one or other of these three heads, History, Philosophy, and Poetry, may undoubtedly be said with considerable plausibility;—the word History being understood to comprehend all our knowledge of particular facts and particular events; the word Philosophy, all the general conclusions or laws inferred from these particulars by induction; and the word Poetry, all the arts addressed to the imagination. Not that the enumeration, even with the help of this comment, can be considered as complete; for, to pass over entirely the other objections already stated, under which of these three heads shall we arrange the various branches of pure mathematics?

Are we therefore to conclude, that the magnificent design, conceived by Bacon, of enumerating, defining, and classifying the multifarious objects of human knowledge;—a design, on the successful accomplishment of which he himself believed that the advancement of the sciences essentially depended;—Are we to conclude, that this design was nothing more than the abortive offspring of a warm imagination, unsusceptible of any useful application to enlighten the mind, or to accelerate its progress? My own idea is widely different. The design was, in every respect, worthy of the sublime genius by which it was formed. Nor does it follow, because the execution was imperfect, that the attempt has been attended with no advantage. At the period when Bacon wrote, it was of much more consequence to exhibit to the learned a comprehensive sketch, than an accurate survey of the intellectual world;—such a sketch as, by pointing out to those whose views had been hitherto confined within the limits of particular regions, the relative positions and bearings of their respective districts as parts of one great whole, might invite them all, for the common benefit, to a reciprocal exchange of their local riches. The societies or academies which, soon after, sprung up in different countries of Europe, for the avowed purpose of contributing to the general mass of information, by the collection of insulated facts, conjectures, and queries, afford sufficient proof, that the anticipations of Bacon were not, in this instance, altogether chimerical.

In examining the details of Bacon's survey, it is impossible not to be struck (more especially when we reflect on the state of learning two hundred years ago) with the minuteness of his information, as well as with the extent of his views; or to forbear admiring his sagacity in pointing out, to future adventurers, the unknown tracks still left to be explored by human curiosity. If his classifications be sometimes artificial and arbitrary, they have at least the merit of including, under one head or another, every particular of importance; and of exhibiting these particulars with a degree of method and of apparent connection, which, if it does not always satisfy the judgment, never fails to interest the fancy, and to lay hold of the memory. Nor must it be forgotten, to the glory of his genius, that what he failed to accomplish remains to this day a desideratum in science;—that the intellectual chart delineated by him is, with all its imperfections, the only one of which modern philosophy has yet to boast;—and that the united talents of D'Alembert and of Diderot, aided by all the lights of the eighteenth century, have been able to add but little to what Bacon performed.

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[1] In justice to the authors of the Encyclopedical Tree prefixed to the French Dictionary, it ought to be observed, that it is spoken of by D'Alembert, in his Preliminary Discourse, with the utmost modesty and diffidence; and that he has expressed, not only his own conviction, but that of his colleague, of the impossibility of executing such a task in a manner likely to satisfy the public. "Nous sommes trop convaincus de l'arbitraire qui régnera toujours dans une pareille division, pour croire que notre système soit l'unique ou le meilleur; il nous suffira que notre travail ne soit pas entièrement désapprouvé par les bons esprits." And, some pages afterwards, "Si le public éclairé donne son approbation à ces changemens, elle sera la récompense de notre docilité; et s'il ne les approuve pas, nous n'en serons que plus convaincus de l'impossibilité de former un Arbre Encyclopédique qui soit au gré de tout le monde."

After the foregoing observations, it will not be expected that an attempt is to be made, in the following Essay, to solve a problem which has so recently baffled the powers of these eminent writers, and which will probably long continue to exercise the ingenuity of our successors. How much remains to be previously done for the improvement of that part of Logic, whose province it is to fix the limits by which contiguous departments of study are defined and separated! And how many unsuspected affinities may be reasonably presumed to exist among sciences, which, to our circumscribed views, appear at present the most alien from each other! The abstract geometry of Apollonius and Archimedes was found, after an interval of two thousand years, to furnish a torch to the physical inquiries of Newton; while, in the further progress of knowledge, the Etymology of Languages has been happily employed to fill up the chasms of Ancient History; and the conclusions of Comparative Anatomy, to illustrate the Theory of the Earth. For my own part, even if the task were executed with the most complete success, I should be strongly inclined to think, that its appropriate place in an Encyclopædia would be as a branch of the article on Logic;—certainly *not* as an *exordium* to the Preliminary Discourse; the enlarged and refined views which it necessarily presupposes being peculiarly unsuitable to that part of the work which may be expected, in the first instance, to attract the curiosity of every reader.

Before concluding this preface, I shall subjoin a few slight strictures on a very concise and comprehensive division of the objects of Human Knowledge, proposed by Mr Locke, as the basis of a new classification of the sciences. Although I do not know that any attempt has ever been made to follow out in detail the general idea, yet the repeated approbation which has been lately bestowed on a division essentially the same, by several writers of the highest rank, renders it in some measure necessary, on the present occasion, to consider how far it is founded on just principles; more especially as it is completely at variance not only with the language and arrangement adopted in these preliminary essays, but with the whole of that plan on which the original projectors, as well as the continuators, of the *Encyclopædia Britannica*, appear to have proceeded. These strictures will, at the same time, afford an additional proof of the difficulty, or rather of the impossibility, in the actual state of logical science, of solving this great problem, in a manner calculated to unite the general suffrages of philosophers.

"All that can fall," says Mr Locke, "within the compass of Human Understanding being either, first, The nature of things as they are in themselves, their relations, and their manner of operation; or, secondly, That which man himself ought to do as a rational and voluntary agent, for the attainment of any end, especially happiness; or, thirdly, The ways and means whereby the knowledge of both the one and the other of these is attained and communicated; I think science may be divided properly into these three sorts:

"1. Φυσιϰη, or Natural Philosophy. The end of this is bare speculative truth; and whatsoever can afford the mind of man any such, falls under this branch, whether it be God himself, angels, spirits, bodies, or any of their affections, as number and figure, &c.

"2. Πϱαϰτιϰη, The skill of right applying our own powers and actions for the attainment of things good and useful. The most considerable under this head is *Ethics*, which is the seeking out those rules and measures of human actions which lead to happiness, and the means to practise them. The end of this is not bare speculation, but right, and a conduct suitable to it.[1]

"3. Σημειωτιϰη, or *the doctrine of signs*, the most usual whereof being words, it is aptly enough termed also Λογιϰη, *Logic*. The business of this is to consider the nature of signs the mind makes use of for the understanding of things, or conveying its knowledge to others.

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[1] From this definition it appears, that as Locke included under the title of *Physics*, not only *Natural Philosophy*, properly so called, but *Natural Theology*, and the *Philosophy of the Human Mind*, so he meant to refer to the head of *Practics*, not only *Ethics*, but all the various *Arts* of life, both mechanical and liberal.

"This seems to me," continues Mr Locke, "*the first and most general, as well as natural*, division of the objects of our understanding; for a man can employ his thoughts about nothing but either the contemplation of *things* themselves, for the discovery of truth; or about the things in his own power, which are his own *actions*, for the attainment of his own ends; or the *signs* the mind makes use of, both in one and the other, and the right ordering of them for its clearer information. All which three, viz. things as they are in themselves knowable; actions as they depend on us, in order to happiness; and the right use of *signs*, in order to knowledge; being *toto cœlo* different, they seemed to me to be the three great provinces of the intellectual world, wholly separate and distinct one from another."[1]

From the manner in which Mr Locke expresses himself in the above quotation, he appears evidently to have considered the division proposed in it as an original idea of his own; and yet the truth is, that it coincides exactly with what was generally adopted by the philosophers of ancient Greece. "The ancient Greek Philosophy," says Mr Smith, "was divided into three great branches, Physics, or Natural Philosophy; Ethics, or Moral Philosophy; and Logic. *This general division*," he adds, "*seems perfectly agreeable to the nature of things.*" Mr Smith afterwards observes, in strict conformity to Locke's definitions (of which, however, he seems to have had no recollection when he wrote this passage), "That, as the human mind and the Deity, in whatever their essence may be supposed to consist, are parts of the great system of the universe, and parts, too, productive of the most important effects, whatever was taught in the ancient schools of Greece, concerning their nature, made a part of the system of physics."[2]

Dr Campbell, in his *Philosophy of Rhetoric*, has borrowed from the Grecian schools the same very extensive use of the words *physics* and *physiology*, which he employs as synonymous terms; comprehending under this title "not merely Natural History, Astronomy, Geography, Mechanics, Optics, Hydrostatics, Meteorology, Medicine, Chemistry, but also Natural Theology and Psychology, which," he observes, "have been, in his opinion, most unnaturally disjoined from Physiology by philosophers." "Spirit," he adds, "which here comprises only the Supreme Being and the human soul, is surely as much included under the notion of natural object as body is; and is knowable to the philosopher purely in the same way, by observation and experience."[3]

A similar train of thinking led the late celebrated M. Turgot to comprehend under the name of Physics, not only Natural Philosophy (as that phrase is understood by the Newtonians), but Metaphysics, Logic, and even History.[4]

Notwithstanding all this weight of authority, it is difficult to reconcile one's self to an arrangement which, while it classes with Astronomy, with Mechanics, with Optics, and with Hydrostatics, the strikingly contrasted studies of Natural Theology and of the Philosophy of the Human Mind, disunites from the two last the far more congenial sciences of Ethics and of Logic. The human mind, it is true, as well as the material world which surrounds it, forms a part of the great system of the Universe; but is it possible to conceive two parts of the same whole more completely dissimilar, or rather more diametrically opposite, in all their characteristical attributes? Is not the one the appropriate field and province of *observation*,—a power habitually awake to all the perceptions and impressions of the bodily organs? And does not the other fall exclusively under the cognisance of *reflection*;—an operation which inverts all the ordinary habits of the understanding, abstracting the thoughts from every sensible object, and even striving to abstract them from every sensible image? What abuse of language can be greater, than to apply a common name to departments of knowledge which invite the curiosity in directions precisely contrary, and which tend to form intellectual talents, which, if not altogether incompatible, are certainly not often found united in the same individual? The word *Physics*, in particular, which, in our language, long and constant use has restricted to the phenomena of Matter, cannot fail to strike every ear as *anomalously*, and therefore *illogically*, applied, when extended to those of Thought and of Consciousness.

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[1] See the concluding chapter of the *Essay on Human Understanding*, entitled, "Of the Division of the Sciences."

[2] *Wealth of Nations*, Book v. chap. i.

[3] *Philosophy of Rhetoric*, Book i. chap. v. Part iii. § 1.

[4] "Sous le nom de sciences physiques je comprends la logique, qui est la connoissance des opérations de notre esprit et de la génération de nos idées; la métaphysique, qui s'occupe de la nature et de l'origine des êtres; et enfin la physique, proprement dite, qui observe l'action mutuelle des corps les uns sur les autres, et les causes et l'enchainement des phénomènes sensibles. *On pourroit y ajouter l'histoire.*"—(*Œuvres de* TURGOT, Tome II. pp. 284, 285.)

In the year 1795, a quarto volume was published at Bath, entitled *Intellectual Physics*. It consists entirely of speculations concerning the human mind, and is by no means destitute of merit. The publication was anonymous; but I have reason to believe that the author was the late well-known Governor Pownall.

Nor let it be imagined that these observations assume any particular theory about the nature or essence of Mind. Whether we adopt, on this point, the language of the Materialists, or that of their opponents, it is a proposition equally certain and equally indisputable, that the phenomena of Mind and those of Matter, as far as they come under the cognisance of our faculties, appear to be more completely heterogeneous than any other classes of facts within the circle of our knowledge; and that the sources of our information concerning them are in every respect so radically different, that nothing is more carefully to be avoided, in the study of either, than an attempt to assimilate them, by means of analogical or metaphorical terms, applied to both in common. In those inquiries, above all, where we have occasion to consider Matter and Mind as conspiring to produce the same joint effects (in the constitution, for example, of our own compounded frame), it becomes more peculiarly necessary to keep constantly in view the distinct province of each, and to remember, that the business of philosophy is not to resolve the phenomena of the one into those of the other, but merely to ascertain the general laws which regulate their mutual connection. *Matter* and *Mind*, therefore, it should seem, are the two most general heads which ought to form the ground-work of an Encyclopedical classification of the sciences and arts. No branch of human knowledge, no work of human skill, can be mentioned, which does not obviously fall under the former head or the latter.

Agreeably to this twofold classification of the sciences and arts, it is proposed, in the following introductory Essays, to exhibit a rapid sketch of the progress made since the revival of letters: *First*, in those branches of knowledge which relate to Mind; and, *secondly*, in those which relate to Matter. D'Alembert, in his Preliminary Discourse, has boldly attempted to embrace both subjects in one magnificent design; and never, certainly, was there a single mind more equal to such an undertaking. The historical outline which he has there traced forms by far the most valuable portion of that performance, and will for ever remain a proud monument to the depth, to the comprehensiveness, and to the singular versatility of his genius. In the present state of science, however, it has been apprehended, that, by dividing so great a work among different hands, something might perhaps be gained, if not in point of reputation to the authors, at least in point of instruction to their readers. This division of labour was, indeed, in some measure, rendered necessary (independently of all other considerations), by the important accessions which mathematics and physics have received since D'Alembert's time;—by the innumerable improvements which the spirit of mercantile speculation, and the rivalship of commercial nations, have introduced into the mechanical arts;—and, above all, by the rapid succession of chemical discoveries, which commences with the researches of Black and of Lavoisier. The part of this task which has fallen to my share is certainly, upon the whole, the least splendid in the results which it has to record; but I am not without hopes, that this disadvantage may be partly compensated by its closer connection with (what ought to be the ultimate end of all our pursuits) the intellectual and moral improvement of the species.

I am, at the same time, well aware that, in proportion as this last consideration increases the importance, it adds to the difficulty of my undertaking. It is chiefly in judging of questions "coming home to their business and bosoms," that casual associations lead mankind astray; and of such associations how incalculable is the number arising from false systems of religion, oppressive forms of government, and absurd plans of education! The consequence is, that while the physical and mathematical discoveries of former ages present themselves to the hand of the historian, like masses of pure and native gold, the truths which we are here in quest of may be compared to *iron*, which, although at once the most necessary and the most widely diffused of all the metals, commonly requires a discriminating eye to detect its existence, and a tedious, as well as nice process, to extract it from the ore.

To the same circumstance it is owing, that improvements in Moral and in Political Science do not strike the imagination with nearly so great force as the discoveries of the Mathematician or of the Chemist. When an inveterate prejudice is destroyed by extirpating the casual associations on which it was grafted, how powerful is the new impulse given to the intellectual faculties of man! Yet how slow and silent the process by which the effect is accomplished! Were it not, indeed, for a certain class of learned authors, who, from time to time, heave the log into the deep, we should hardly believe that the reason of the species is progressive. In this respect, the religious and academical establishments in some parts of Europe are not without their use to the Historian of the Human Mind. Immoveably moored to the same station by the strength of their cables, and the weight of their anchors, they enable him to measure the rapidity of the current by which the rest of the world are borne along.

This, too, is remarkable in the history of our prejudices; that, as soon as the film falls from the intellectual eye, we are apt to lose all recollection of our former blindness. Like the fantastic and giant shapes which, in a thick fog, the imagination lends to a block of stone, or to the stump of a tree, they produce, while the illusion lasts, the same effect with truths and realities; but the moment the eye has caught the exact form and dimensions of its object, the spell is broken for ever; nor can any effort of thought again conjure up the spectres which have vanished.

As to the subdivisions of which the sciences of Matter and of Mind are susceptible, I have already said, that this is not the proper place for entering into any discussion concerning them. The passages above quoted from D'Alembert, from Locke, and from Smith, are sufficient to show how little probability there is, in the actual state of Logical Science, of uniting the opinions of the learned in favour of any one scheme of partition. To prefix, therefore, such a scheme to a work which is professedly to be carried on by a set of unconnected writers, would be equally presumptuous and useless; and, on the most favourable supposition, could tend only to fetter, by means of dubious definitions, the subsequent freedom of thought and of expression. The example of the French *Encyclopédie* cannot here be justly alleged as a precedent. The preliminary pages by which it is introduced were written by the two persons who projected the whole plan, and who considered themselves as responsible, not only for their own admirable articles, but for the general conduct of the execution; whereas, on the present occasion, a porch was to be adapted to an irregular edifice, reared, at different periods, by different architects. It seemed, accordingly, most advisable to avoid, as much as possible, in these Introductory Essays, all innovations in language, and, in describing the different arts and sciences, to follow scrupulously the prevailing and most intelligible phraseology. The task of defining them, with a greater degree of precision, properly devolves upon those to whose province it belongs, in the progress of the work, to unfold in detail their elementary principles.

The sciences to which I mean to confine my observations are Metaphysics, Ethics, and Political Philosophy; understanding, by Metaphysics, not the Ontology and Pneumatology of the schools, but the inductive Philosophy of the Human Mind; and limiting the phrase Political Philosophy almost exclusively to the modern science of Political Economy; or (to express myself in terms at once more comprehensive and more precise) to that branch of the theory of legislation which, according to Bacon's definition, aims to ascertain those "Leges legum, ex quibus informatio peti potest quid in singulis legibus bene aut perperam positum aut constitutum sit." The close affinity between these three departments of knowledge, and the easy transitions by which the curiosity is invited from the study of any one of them to that of the other two, will sufficiently appear from the following Historical Review.

DISSERTATION FIRST.

PART FIRST.

In the following Historical and Critical Sketches, it has been judged proper by the different writers, to confine their views entirely to the period which has elapsed since the *revival of letters*. To have extended their retrospects to the ancient world would have crowded too great a multiplicity of objects into the limited canvas on which they had to work. For my own part, I might, perhaps with still greater propriety, have confined myself exclusively to the two last centuries; as the Sciences of which I am to treat, present but little matter for useful remark, prior to the time of Lord Bacon. I shall make no apology, however, for devoting, in the first place, a few pages to some observations of a more general nature, and to some scanty gleanings of literary detail, bearing more or less directly on my principal design.

On this occasion, as well as in the sequel of my Discourse, I shall avoid, as far as is consistent with distinctness and perspicuity, the minuteness of the mere bibliographer; and, instead of attempting to amuse my readers with a series of critical epigrams, or to dazzle them with a rapid succession of evanescent portraits, shall study to fix their attention on those great *lights of the world* by whom the torch of science has been successively seized and transmitted.[1] It is, in fact, such leading characters alone which furnish matter for philosophical history. To enumerate the names or the labours of obscure or even secondary authors, whatever amusement it might afford to men of curious erudition, would contribute but little to illustrate the origin and filiation of consecutive systems, or the gradual developement and progress of the human mind.

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[1] I have ventured here to combine a scriptural expression with an allusion of Plato's to a Grecian game;—an allusion which, in his writings, is finely and pathetically applied to the rapid succession of generations, through which the continuity of human life is maintained from age to age; and which are perpetually transferring from hand to hand the concerns and duties of this fleeting scene. Γεννῶντες τε καὶ ἐκτρέφοντες παῖδας, καθάπερ λαμπάδα τὸν βίον παραδιδόντες ἄλλοις ἐξ ἄλλων.—(Plato, *Leg.* lib. vi.)

Et quasi cursores vitaï lampada tradunt.—Lucret.

CHAPTER I.

FROM THE REVIVAL OF LETTERS TO THE PUBLICATION OF BACON'S PHILOSOPHICAL WORKS.

The long interval, commonly known by the name of the *middle ages*, which immediately preceded the revival of letters in the western part of Europe, forms the most melancholy blank which occurs, from the first dawn of recorded civilisation, in the intellectual and moral history of the human race. In one point of view alone, the recollection of it is not altogether unpleasing, inasmuch as, by the proof it exhibits of the inseparable connection between ignorance and prejudice on the one hand, and vice, misery, and slavery on the other, it affords, in conjunction with other causes, which will afterwards fall under our review, some security against any future recurrence of a similar calamity.

It would furnish a very interesting and instructive subject of speculation, to record and to illustrate (with the spirit, however, rather of a philosopher than of an antiquary), the various abortive efforts, which, during this protracted and seemingly hopeless period of a thousand years, were made by enlightened individuals, to impart to their contemporaries the fruits of their own acquirements. For in no one age from its commencement to its close, does *the continuity of knowledge* (if I may borrow an expression of Mr Harris), seem to have been entirely interrupted: "There was always a faint twilight, like that auspicious gleam which, in a summer's night, fills up the interval between the setting and the rising sun."[1] On the present occasion, I shall content myself with remarking the important effects produced by the numerous monastic establishments all over the Christian world, in preserving, amidst the general wreck, the inestimable remains of Greek and Roman refinement, and in keeping alive, during so many centuries, those scattered sparks of truth and of science, which were afterwards to kindle into so bright a flame. I mention this particularly, because, in our zeal against the vices and corruptions of the Romish church, we are too apt to forget, how deeply we are indebted to its superstitious and apparently useless foundations, for the most precious advantages that we now enjoy.

The study of the Roman Law, which, from a variety of causes, natural as well as accidental, became, in the course of the twelfth century, an object of general pursuit, shot a strong and auspicious ray of intellectual light across the surrounding darkness. No study could then have been presented to the curiosity of men, more happily adapted to improve their taste, to enlarge their views, or to invigorate their reasoning powers; and although, in the first instance, prosecuted merely as the object of a weak and undistinguishing idolatry, it nevertheless conducted the student to the very confines of ethical as well as of political speculation; and served, in the meantime, as a substitute of no inconsiderable value for both these sciences. Accordingly we find that, while in its *immediate* effects it powerfully contributed, wherever it struck its roots, by ameliorating and systematizing the administration of justice, to accelerate the progress of order and of civilization, it afterwards furnished, in the further career of human advancement, the parent stock on which were grafted the first rudiments of pure ethics and of liberal politics taught in modern times. I need scarcely add, that I allude to the systems of *natural jurispru-*

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[1] *Philological Inquiries*, Part III. chap. i.

dence compiled by Grotius and his successors;—systems which, for a hundred and fifty years, engrossed all the learned industry of the most enlightened part of Europe; and which, however unpromising in their first aspect, were destined, in the last result, to prepare the way for that never to be forgotten change in the literary taste of the eighteenth century, "which has everywhere turned the spirit of philosophical inquiry from frivolous or abstruse speculations, to the business and affairs of men."[1]

The revival of letters may be considered as coeval with the fall of the Eastern empire, towards the close of the fifteenth century. In consequence of this event, a number of learned Greeks took refuge in Italy, where the taste for literature already introduced by Dante, Petrarch, and Boccacio, together with the liberal patronage of the illustrious House of Medicis, secured them a welcome reception. A knowledge of the Greek tongue soon became fashionable; and the learned, encouraged by the rapid diffusion which the art of printing now gave to their labours, vied with each other in rendering the Greek authors accessible, by means of Latin translations, to a still wider circle of readers.

For a long time, indeed, after the era just mentioned, the progress of useful knowledge was extremely slow. The passion for logical disputation was succeeded by an unbounded admiration for the wisdom of antiquity; and in proportion as the pedantry of the schools disappeared in the universities, that of erudition and philology occupied its place.

Meanwhile, an important advantage was gained in the immense stock of materials which the ancient authors supplied to the reflections of speculative men; and which, although frequently accumulated with little discrimination or profit, were much more favourable to the developement of taste and of genius than the unsubstantial subtleties of ontology or of dialectics. By such studies were formed Erasmus,[2] Ludovicus Vives,[3] Sir Thomas More,[4] and many other accomplished scholars of a similar character, who, if they do not rank in the same line with the daring reformers by whom the errors of the Catholic church were openly assailed, certainly exhibit a very striking contrast to the barbarous and unenlightened writers of the preceding age.

The Protestant Reformation, which followed immediately after, was itself one of the natural consequences of the revival of letters, and of the invention of printing. But although, in one point of view, only an *effect*, it is not, on the present occasion, less entitled to notice than the *causes* by which it was produced.

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[1] Dr Robertson, from whom I quote these words, has mentioned this change as the glory of the *present age*, meaning, I presume, the period which has elapsed since the time of Montesquieu. By what steps the philosophy to which he alludes took its rise from the systems of jurisprudence previously in fashion, will appear in the sequel of this Discourse.

[2] The writings of Erasmus probably contributed still more than those of Luther himself to the progress of the Reformation among men of education and taste; but, without the co-operation of bolder and more decided characters than his, little would to this day have been effected in Europe among the lower orders. "Erasmus imagined," as is observed by his biographer, "that at length, by training up youth in learning and useful knowledge, those religious improvements would gradually be brought about, which the Princes, the Prelates, and the Divines of his days could not be persuaded to admit or to tolerate."—(JORTIN, p. 279.) In yielding, however, to this pleasing expectation, Erasmus must have flattered himself with the hope, not only of a perfect freedom of literary discussion, but of such reforms in the prevailing modes of instruction, as would give complete scope to the energies of the human mind;—for, where books and teachers are subjected to the censorship of those who are hostile to the dissemination of truth, they become the most powerful of all auxiliaries to the authority of established errors.

It was long a proverbial saying among the ecclesiastics of the Romish church, that "Erasmus laid the egg, and Luther hatched it;" and there is more truth in the remark, than in most of their sarcasms on the same subject.

[3] Ludovicus Vives was a learned Spaniard, intimately connected both with Erasmus and More; with the former of whom he lived for some time at Louvain, "where they both promoted literature as much as they could, though not without great opposition from some of the divines."—JORTIN, p. 255.

"He was invited into England by Wolsey, in 1523; and coming to Oxford, he read the Cardinal's lecture of *Humanity*, and also lectures of Civil Law, which Henry VIII. and his Queen, Catherine, did him the honour of attending.—(*Ibid.* p. 207.) He died at Bruges in 1554.

In point of good sense and acuteness, wherever he treats of philosophical questions, he yields to none of his contemporaries; and in some of his anticipations of the future progress of science, he discovers a mind more comprehensive and sagacious than any of them. Erasmus appears, from a letter of his to Budæus, dated in 1521, to have foreseen the brilliant career which Vives, then a very young man, was about to run. "Vives in stadio literario, non minus feliciter quam gnaviter decertat, et si satis ingenium hominis novi, non conquiescet, donec omnes a tergo reliquerit."—For this letter (the whole of which is peculiarly interesting, as it contains a character of Sir Thomas More, and an account of the extraordinary accomplishments of his daughters), See JORTIN's *Life of Erasmus*, Vol. II. p. 366. *et seq.*

[4] See Note A.

The renunciation, in a great part of Europe, of theological opinions so long consecrated by time, and the adoption of a creed more pure in its principles and more liberal in its spirit, could not fail to encourage, on all other subjects, a congenial freedom of inquiry. These circumstances operated still more directly and powerfully, by their influence, in undermining the authority of Aristotle;—an authority which for many years was scarcely inferior in the schools to that of the Scriptures; and which, in some Universities, was supported by statutes, requiring the teachers to promise upon oath, that in their public lectures, they would follow no other guide.

Luther,[1] who was perfectly aware of the corruptions which the Romish church had contrived to connect with their veneration for the Stagirite,[2] not only threw off the yoke himself, but, in various parts of his writings, speaks of Aristotle with the most unbecoming asperity and contempt.[3] In one very remarkable passage, he asserts, that the study of Aristotle was wholly useless, not only in Theology, but in Natural Philosophy. "What does it contribute," he asks, "to the knowledge of things, to trifle and cavil in language conceived and prescribed by Aristotle, concerning matter, form, motion, and time?"[4] The same freedom of thought on topics not strictly theological, formed a prominent feature in the character of Calvin. A curious instance of it occurs in one of his letters, where he discusses an ethical question of no small moment in the science of political economy;—"How far it is consistent with morality to accept of interest for a pecuniary loan?" On this question, which, even in Protestant countries, continued, till a very recent period, to divide the opinions both of divines and lawyers, Calvin treats the authority of Aristotle and that of the church with equal disregard. To the former he opposes a close and logical argument, not unworthy of Mr Bentham. To the latter he replies, by showing, that the Mosaic law on this point was not a moral but a municipal prohibition; a prohibition not to be judged of from any particular text of Scripture, but upon the principles of natural equity.[5] The example of these two Fathers of the Reformation would probably have been followed by consequences still greater and more immediate, if Melanchthon had not unfortunately given the sanction of his name to the doctrines of the Peripatetic school:[6] but still, among the Reformers in general, the credit of these doctrines gradually declined, and a spirit of research and of improvement prevailed.

The invention of printing, which took place very nearly at the same time with the fall of the Eastern Empire, besides adding greatly to the efficacy of the causes above-mentioned, must have been attended with very important effects of its own, on the progress of the human mind. For us who have been accustomed, from our infancy, to the use of books, it is not easy to form an adequate idea of the disadvantages which those laboured under, who had to acquire the whole of their knowledge through the medium of universities and schools;—blindly devoted as the generality of students must then have been to the peculiar opinions of the teacher who first unfolded to their curiosity the treasures of literature and the wonders of science. Thus error was perpetuated; and, instead of yielding to time, acquired additional influence in each successive generation.[1] In modern times, this influence of names is, comparatively speaking, at an end. The object of a public teacher is no longer to inculcate a particular system of dogmas, but to prepare his pupils for exercising their own judgments; to exhibit to them an outline of the different sciences, and to suggest subjects for their future examination. The few attempts to establish schools and to found sects, have all, after perhaps a temporary success, proved abortive. Their effect, too, during their short continuance, has been perfectly the reverse of that of the schools of antiquity; for whereas these were instrumental, on many occasions, in establishing and diffusing error in the world, the founders of our modern sects, by mixing up important truths with their own peculiar tenets, and by disguising them under the garb of a technical phraseology, have fostered such prejudices against themselves, as have blinded the public mind to all the lights they were able to communicate. Of this remark a melancholy illustration occurs, as M. Turgot long ago predicted, in the case of the French Economists; and many examples of a similar import might be produced from the history of science in our country; more particularly from the history of the various medical and metaphysical schools which successively rose and fell during the last century.

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[1] Born 1483, died 1546.

[2] In one of his letters he writes thus: "Ego simpliciter credo, quod impossibile sit ecclesiam reformari, nisi funditus canones, decretales, scholastica theologia, philosophia, logica, ut nunc habentur, eradicentur, et alia instituantur."—Bruckeri *Hist. Crit. Phil.* Tom. IV. p. 95.

[3] For a specimen of Luther's scurrility against Aristotle, see Bayle, Art. *Luther*, Note HH.

In Luther's *Colloquia Mensalia* we are told, that "he abhorred the Schoolmen, and called them sophistical locusts, caterpillars, frogs, and lice." From the same work we learn, that "he hated Aristotle, but highly esteemed Cicero, as a wise and a good man."—See Jortin's *Life of Erasmus*, p. 121.

[4] "Nihil adjumenti ex ipso haberi posse non solum ad theologiam seu sacras literas, verum etiam ad ipsam naturalem philosophiam. Quid enim juvet ad rerum cognitionem, si de materia, forma, motu, tempore, nugari et cavillari queas verbis ab Aristotele conceptis et præscriptis?"—Bruck. *Hist. Phil.* Tom. IV. p. 101.

The following passage to the same purpose is quoted by Bayle: "Non mihi persuadebitis, philosophiam esse garrulitatem illam de materia, motu, infinito, loco, vacuo, tempore, quæ fere in Aristotele sola discimus, talia quæ nec intellectum, nec affectum, nec communes hominum mores quidquam juvent; tantum contentionibus serendis, seminandisque idonea."—Bayle, Art. *Luther*, Note HH.

I borrow from Bayle another short extract from Luther: "Nihil ita ardet animus, quam histrionem illum (Aristotelem), qui tam vere Græca larva ecclesiam lusit, multis revelare, ignominiamque ejus cunctis ostendere, si otium esset. Habeo in manus commentariolos in 1. Physicorum, quibus fabulam Aristæi denuo agere statui in meum istum Protea (Aristotelem). Pars crucis meæ vel maxima est, quod videre cogor fratrum optima ingenia, bonis studiis nata, in istis cœnis vitam agere, et operam perdere."—*Ibid.*

That Luther was deeply skilled in the scholastic philosophy we learn from very high authority, that of Melanchthon; who tells us farther, that he was a strenuous partizan of the sect of *Nominalists*, or, as they were then generally called, *Terminists.*—Bruck. Tom. IV. pp. 93, 94, *et seq.*

[5] See Note B.

[6] "Et Melanchthoni quidem præcipue debetur conservatio philosophiæ Aristotelicæ in academiis protestantium. Scripsit is compendia plerarumque disciplinarum philosophiæ Aristotelicæ, quæ in Academiis diu regnarunt."—Heineccii, *Elem. Hist. Phil.* § ciii. See also Bayle's *Dictionary*, Art. *Melanchthon.*

With the circumstances already suggested, as conspiring to accelerate the progress of knowledge, another has co-operated very extensively and powerfully; the rise of the lower orders in the different countries of Europe,—in consequence partly of the enlargement of commerce, and partly of the efforts of the Sovereigns to reduce the overgrown power of the feudal aristocracy.

Without this emancipation of the lower orders, and the gradual diffusion of wealth by which it was accompanied, the advantages derived from the invention of printing would have been extremely limited. A certain degree of ease and independence is essentially requisite to inspire men with the desire of knowledge, and to afford the leisure necessary for acquiring it; and it is only by the encouragement which such a state of society presents to industry and ambition, that the selfish passions of the multitude can be interested in the intellectual improvement of their children. It is only, too, in such a state of society, that education and books are likely to increase the sum of human happiness; for while these advantages are confined to one privileged description of individuals, they but furnish them with an additional engine for debasing and misleading the minds of their inferiors. To all which it may be added, that it is chiefly by the shock and collision of different and opposite prejudices, that truths are gradually cleared from that admixture of error which they have so strong a tendency to acquire, wherever the course of public opinion is forcibly constrained and guided within certain artificial channels, marked out by the narrow views of human policy. The diffusion of knowledge, therefore, occasioned by the rise of the lower orders, would necessarily contribute to the improvement of useful science, not merely in proportion to the arithmetical number of cultivated minds now combined in the pursuit of truth, but in a proportion tending to accelerate that important effect with a far greater rapidity.

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[1] It was in consequence of this mode of conducting education by means of oral instruction alone, that the different sects of philosophy arose in ancient Greece; and it seems to have been with a view of counteracting the obvious inconveniences resulting from them, that Socrates introduced his peculiar method of questioning, with an air of sceptical diffidence, those whom he was anxious to instruct; so as to allow them, in forming their conclusions, the complete and unbiassed exercise of their own reason. Such, at least, is the apology offered for the apparent indecision of the Academic school, by one of its wisest as well as most eloquent adherents. "As for other sects," says Cicero, "who are bound in fetters, before they are able to form any judgment of what is right or true, and who have been led to yield themselves up, in their tender years, to the guidance of some friend, or to the captivating eloquence of the teacher whom they have first heard, they assume to themselves the right of pronouncing upon questions of which they are completely ignorant; adhering to whatever creed the wind of doctrine may have driven them, as if it were the only rock on which their safety depended."—Cic. *Lucullus*, 3.

Nor ought we here to overlook the influence of the foregoing causes, in encouraging among authors the practice of addressing the multitude in their own vernacular tongues. The zeal of the Reformers first gave birth to this invaluable innovation, and imposed on their adversaries the necessity of employing, in their own defence, the same weapons.[1] From that moment the prejudice began to vanish which had so long confounded knowledge with erudition; and a revolution commenced in the republic of letters, analogous to what the invention of gunpowder produced in the art of war. "All the splendid distinctions of mankind," as the Champion and Flower of Chivalry indignantly exclaimed, "were thereby thrown down; and the naked shepherd levelled with the knight clad in steel."

To all these considerations may be added the gradual effects of time and experience in correcting the errors and prejudices which had misled philosophers during so long a succession of ages. To this cause, chiefly, must be ascribed the ardour with which we find various ingenious men, soon after the period in question, employed in prosecuting *experimental* inquiries; a species of study to which nothing analogous occurs in the history of ancient science.[2] The boldest and most successful of this new school was the celebrated Paracelsus, born in 1493, and consequently only ten years younger than Luther. "It is impossible to doubt," says Le Clerc, in his *History of Physic*, "that he possessed an extensive knowledge of what is called the *Materia Medica*, and that he had employed much time in working on the animal, the vegetable, and the mineral substances of which it is composed. He seems, besides, to have tried an immense number of experiments in chemistry; but he has this great defect, that he studiously conceals or disguises the results of his long experience." The same author quotes from Paracelsus a remarkable expression, in which he calls the philosophy of Aristotle *a wooden foundation*. "He ought to have attempted," continues Le Clerc, "to have laid a better; but if he has not done it, he has at least, by discovering its weakness, invited his successors to look out for a firmer basis."[5]

Lord Bacon himself, while he censures the moral frailties of Paracelsus, and the blind empiricism of his followers, indirectly acknowledges the extent of his experimental information: "The ancient sophists may be said to have hid, but Paracelsus extinguished the light of nature. The sophists were only deserters of experience, but Paracelsus has betrayed it. At the same time, he is so far from understanding the right method of conducting experiments, or of recording their results, that he has added to the trouble and tediousness of experimenting. By wandering through the wilds of experience, his disciples sometimes stumble upon useful discoveries, not by reason, but by accident;—whence rashly proceeding to form theories, they carry the smoke and tarnish of their art along with them; and, like childish operators at the furnace, attempt to raise a structure of philosophy with a few experiments of distillation."

Two other circumstances, of a nature widely different from those hitherto enumerated, although, probably, in no small degree to be accounted for on the same principles, seconded, with an incalculable accession of power, the sudden impulse which the human mind had just received. The same century which the invention of printing and the revival of letters have made for ever memorable, was also illustrated by the discovery of the New World, and of the passage to India by the Cape of Good Hope;—events which may be justly regarded as fixing a new era in the political and moral history of mankind, and which still continue to exert a growing influence over the general condition of our species. " It is an era," as Raynal observes, " which gave rise to a revolution, not only in the commerce of nations, but in the manners, industry, and government of the world. At this period new connections were formed by the inhabitants of the most distant regions, for the supply of wants which they had never before experienced. The productions of climates situated under the equator, were consumed in countries bordering on the pole; the industry of the north was transplanted to the south; and the inhabitants of the west were clothed with the manufactures of the east; a general intercourse of opinions, laws and customs, diseases and remedies, virtues and vices, was established among men."

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[1] "The sacred books were, in almost all the kingdoms and states of Europe, translated into the language of each respective people, particularly in Germany, Italy, France, and Britain."—(MOSHEIM's *Eccles. Hist.* Vol. III. p. 265.) The effect of this single circumstance in multiplying the number of readers and of thinkers, and in giving a certain stability to the mutable forms of oral speech, may be easily imagined. The common translation of the Bible into English is pronounced by Dr Lowth to be still the best standard of our language.

[2] "Hæc nostra (ut sæpe diximus) felicitatis cujusdam sunt potius quam facultatis, *et potius temporis partus quam ingenii.*"—*Nov. Org.* Lib. i. c. xxiii.

[3] Histoire de la Médecine (à la Haye, 1729), p. 819.

" Every thing," continues the same writer, " has changed, and must yet change more. But it is a question, whether the revolutions that are past, or those which must hereafter take place, have been, or can be, of any utility to the human race. Will they add to the tranquillity, to the enjoyments, and to the happiness of mankind? Can they improve our present state, or do they only change it?"

I have introduced this quotation, not with the design of attempting at present any reply to the very interesting question with which it concludes, but merely to convey some slight notion of the political and moral importance of the events in question. I cannot, however, forbear to remark, in addition to Raynal's eloquent and impressive summary, the inestimable treasure of new facts which these events have furnished for illustrating the versatile nature of man, and the history of civil society. In this respect (as Bacon has well observed) they have fully verified the Scripture prophecy, *multi pertransibunt et augebitur scientia;* or, in the still more emphatical words of our English version, " Many shall go to and fro, and knowledge shall be increased."[1] The same prediction may be applied to the gradual renewal, (in proportion as modern governments became effectual in securing order and tranquillity) of that intercourse between the different states of Europe, which had, in a great measure, ceased during the anarchy and turbulence of the middle ages.

In consequence of these combined causes, aided by some others of secondary importance,[2] the Genius of the human race seems, all at once, to have awakened with renovated and giant strength, from his long sleep. In less than a

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[1] " Neque omittenda est prophetia Danielis de ultimis mundi temporibus; *multi pertransibunt et augebitur scientia:* Manifeste innuens et significans, esse in fatis, id est, in providentia, ut pertransitus mundi (qui per tot longinquas navigationes impletur plane, aut jam in opere esse videtur) et augmenta scientiarum in eandem ætatem incidant."—*Nov. Org.* Lib. xciii.

[2] Such as the *accidental* inventions of the telescope and of the microscope. The powerful influence of these inventions may be easily conceived, not only in advancing the sciences of Astronomy and of Natural History, but in banishing many of the scholastic prejudices then universally prevalent. The effects of the telescope, in this respect, have been often remarked; but less attention has been given to those of the microscope, which, however, it is probable, contributed not a little to prepare the way for the modern revival of the Atomic or Corpuscular Philosophy, by Bacon, Gassendi, and Newton. That, on the mind of Bacon, the wonders disclosed by the microscope produced a strong impression in favour of the Epicurean physics, may be inferred from his own words. " Perspicillum (microscopicum) si vidisset Democritus, exsiluisset forte; et modum videndi Atomum, quem ille invisibilem omnino affirmavit, inventum fuisse putasset."—*Nov. Org.* Lib. ii. § 39.

We are told in the Life of Galileo, that when the telescope was invented, some individuals carried to so great a length their devotion to Aristotle, that they positively refused to look through that instrument: so averse were they to open their eyes to any truths inconsistent with their favourite creed.—(*Vita di Galileo*, Venezia, 1744). It is amusing to find some other followers of the Stagirite, a very few years afterwards, when they found it impossible any longer to call in question the evidence of sense, asserting that it was from a passage in Aristotle, where he attempts to explain why stars become visible in the day-time when viewed from the bottom of a deep well, that the invention of the telescope was borrowed. The two facts, when combined, exhibit a truly characteristical portrait of one of the most fatal weaknesses incident to humanity; and form a moral apologue, daily exemplified on subjects of still nearer and higher interest than the phenomena of the heavens.

In ascribing to *accident* the inventions of the telescope and of the microscope, I have expressed myself in conformity to common language; but it ought not to be overlooked, that an invention may be accidental with respect to the particular author, and yet may be the natural result of the circumstances of society at the period when it took place. As to the instruments in question, the combination of lenses employed in their structure is so simple, that it could scarcely escape the notice of *all* the experimenters and mechanicians of that busy and inquisitive age. A similar remark has been made by century from the invention of printing, and the fall of the Eastern empire, Copernicus discovered the true theory of the planetary motions, and a very few years afterwards, was succeeded by the three great precursors of Newton,—Tycho Brahe, Kepler, and Galileo.

The step made by Copernicus may be justly regarded as one of the proudest triumphs of human reason;—whether we consider the sagacity which enabled the author to obviate, to his own satisfaction, the many plausible objections which must have presented themselves against his conclusions, at a period when the theory of motion was so imperfectly understood; or the bold spirit of inquiry which encouraged him to exercise his private judgment, in opposition to the authority of Aristotle,—to the decrees of the church of Rome,—and to the universal belief of the learned, during a long succession of ages. He appears, indeed, to have well merited the encomium bestowed on him by Kepler, who calls him "a man of vast genius, and, what is of still greater moment in these researches, a man of a free mind."

The establishment of the Copernican system, beside the new field of study which it opened to Astronomers, must have had great effects on philosophy in all its branches, by inspiring those sanguine prospects of future improvement, which stimulate curiosity, and invigorate the inventive powers. It afforded to the common sense, even of the illiterate, a palpable and incontrovertible proof, that the ancients had not exhausted the stock of possible discoveries; and that, in matters of science, the creed of the Romish church was not infallible. In the conclusion of one of Kepler's works, we perceive the influence of these prospects on his mind. "Hæc et cetera hujusmodi latent in pandectis ævi sequentis, non antea discenda, quam librum hunc Deus arbiter sæculorum recluserit mortalibus."[1]

I have hitherto taken no notice of the effects of the revival of letters on Metaphysical, Moral, or Political science. The truth is, that little deserving of our attention occurs in any of these departments prior to the seventeenth century; and nothing which bears the most remote analogy to the rapid strides made, during the sixteenth, in mathematics, astronomy, and physics. The influence, indeed, of the Reformation on the *practical* doctrines of ethics appears to have been great and immediate. We may judge of this from a passage in Melanchthon, where he combats the pernicious and impious tenets of those theologians who maintained, that moral distinctions are created entirely by the arbitrary and revealed will of God. In opposition to this heresy, he expresses himself in these memorable words:—"Wherefore our decision is this; that those precepts which learned men have committed to writing, transcribing them from the common reason and common feelings of human nature, are to be accounted as not less divine, than those contained in the tables given to Moses; and that it could not be the intention of our Maker to supersede, by a law graven upon stone, that which is written with his own finger on the table of the heart."[2]—This language was, undoubtedly, a most important step towards a just system of Moral Philosophy; but still, like the other steps of the Reformers, it was only a return to common sense, and to the genuine spirit of Christianity, from the dogmas imposed on the credulity of mankind by an ambitious priesthood.[3] Many years were yet to elapse, before

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Condorcet concerning the invention of printing. "L'invention de l'Imprimerie a sans doute avancé le progrès de l'espèce humaine; mais cette invention étoit elle-même une suite de l'usage de la lecture répandu dans un grand nombre de pays."—*Vie de Turgot.*

[1] *Epit. Astron. Copernic.*

[2] Proinde sic statuimus, nihilo minus divina præcepta esse ea, quæ a sensu communi et naturæ judicio mutuati docti homines gentiles literis mandarunt, quam quæ extant in ipsis saxeis Mosis tabulis. Neque ille ipse cælestis Pater pluris a nobis fieri eas leges voluit, quas in saxo scripsit, quam quas in ipsos animorum nostrorum sensus impresserat."

Not having it in my power at present to consult Melanchthon's works, I have transcribed the foregoing paragraph on the authority of a learned German Professor, Christ. Meiners.—See his *Historia Doctrinæ de Vero Deo.* Lemgoviæ, 1780, p. 12.

[3] It is observed by Dr Cudworth, that the doctrine which refers the origin of moral distinctions to the arbitrary appointment of the Deity, was strongly reprobated by the ancient fathers of the Christian church, and that "it crept up afterward in the scholastic ages; Occam being among the first that maintained that there is no act evil, but as it is prohibited by God, and which cannot be made good, if it be commanded by him. In this doctrine he was quickly followed by Petrus Alliacus, Andreas de Novo Castro, and others."—See *Treatise of Immutable Morality.*

It is pleasing to remark, how very generally the heresy here ascribed to Occam is now reprobated by good men of all any attempts were to be made to trace, with analytical accuracy, the moral phenomena of human life to their first principles in the constitution and condition of man, or even to disentangle the plain and practical lessons of ethics from the speculative and controverted articles of theological systems.[1]

A similar observation may be applied to the powerful appeals, in the early Protestant writers, to the moral judgment and moral feelings of the human race, from those casuistical subtleties, with which the schoolmen and monks of the middle ages had studied to obscure the light of nature, and to stifle the voice of conscience. These subtleties were precisely analogous in their spirit to the *pia et religiosa calliditas*, afterwards adopted in the casuistry of the Jesuits, and so inimitably exposed by Pascal in the *Provincial Letters.* The arguments against them employed by the Reformers, cannot, in strict propriety, be considered as positive accession to the stock of human knowledge; but what scientific discoveries can be compared to them in value![2]

From this period may be dated the decline[3] of that worst of all heresies of the Romish church, which, by opposing Revelation to Reason, endeavoured to extinguish the light of both; and the absurdity, so happily described by Locke, became every day more manifest, of attempting "to persuade men to put out their eyes, that they might the better receive the remote light of an invisible star by a telescope."

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persuasions. The Catholics have even begun to recriminate on the Reformers as the first broachers of it; and it is to be regretted, that in *some* of the writings of the latter, too near approaches to it are to be found. The truth is, as Burnet long ago observed, that the effects of the Reformation have not been confined to the reformed churches;—to which it may be added, that both Catholics and Protestants have, since that era, profited very largely by the general progress of the sciences and of human reason.

I quote the following sentence from a highly respectable Catholic writer on the law of nature and nations:—"Qui rationem exsulare jubent a moralibus præceptis quæ in sacris literis traduntur, et in absurdam enormemque LUTHERI sententiam imprudentes incidunt (quam egregie et elegantissime refutavit Melchior Canus *Loc. Theolog.* Lib. ix. et x.), et ea docent, quæ si sectatores inveniant moralia omnia susque deque miscere, ac revelationem ipsam inutilem omnino et inefficacem reddere possent."—(LAMPREDI FLORENTINI *Juris Naturæ et Gentium Theoremata*, Tom. II. p. 195. Pisis, 1782). For the continuation of the passage, which would do credit to the most liberal Protestant, I must refer to the original work. The zeal of Luther for the doctrine of the Nominalists had probably prepossessed him, in his early years, in favour of some of the theological tenets of Occam, and afterwards prevented him from testifying his disapprobation of them so explicitly and decidedly as Melanchthon and other reformers have done.

[1] "The theological system (says the learned and judicious Mosheim) that *now* prevails in the Lutheran academies, is not of the same tenor or spirit with that which was adopted in the infancy of the Reformation. The glorious defenders of religious liberty, to whom we owe the various blessings of the Reformation, could not, at once, behold the truth in all its lustre, and in all its extent; but, as usually happens to persons that have been long accustomed to the darkness of ignorance, their approaches towards knowledge were but slow, and their views of things but imperfect."—(MACLAINE's *Transl. of Mosheim.* London, 2d ed. Vol. IV. p. 19.) He afterwards mentions one of Luther's early disciples (Amsdorff) "who was so far transported and infatuated by his excessive zeal for the supposed doctrine of his master, as to maintain, that *good works are an impediment to salvation.*"—*Ibid.* p. 39.

Mosheim, after remarking that "there are more excellent rules of conduct in the few practical productions of Luther and Melanchthon, than are to be found in the innumerable volumes of all the ancient *casuists* and *moralisers*," candidly acknowledges, "that the notions of these great men concerning the important science of morality were far from being sufficiently accurate or extensive. Melanchthon himself, whose exquisite judgment rendered him peculiarly capable of reducing into a compendious system the elements of every science, never seems to have thought of treating morals in this manner; but has inserted, on the contrary, all his practical rules and instructions, under the theological articles that relate to the *law*, *sin*, *free-will*, *faith*, *hope*, *and charity*."—MOSHEIM's *Eccles. Hist.* Vol. IV. pp. 23. 24.

The same author elsewhere observes, that "the progress of morality among the reformed was obstructed by the very same means that retarded its improvement among the Lutherans; and that it was left in a rude and imperfect state by Calvin and his associates. It was neglected amidst the tumult of controversy; and, while every pen was drawn to maintain certain systems of doctrine, few were employed in cultivating that master-science which has *virtue*, *life*, and *manners*, for its objects."—*Ibid.* pp. 120. 121.

[2] "Et tamen hi doctores *angelici*, *cherubici*, *seraphici*, non modo universam philosophiam ac theologiam erroribus quamplurimis inquinarunt: verum etiam in philosophiam moralem invexere sacerrima ista principia *probabilismi*, *methodi dirigendi intentionem*, *reservationis mentalis*, *peccati philosophici*, quibus Jesuitæ etiamnum mirifice delectantur."—HEINECC. *Elem. Histor. Phil.* § ci. See also the references.

With respect to the ethics of the Jesuits, which exhibit a very fair picture of the general state of that science, prior to the Reformation, See the *Provincial Letters;* MOSHEIM's *Ecclesiastical History*, Vol. IV. p. 354; DORNFORD's *Translation of Putter's Historical Developement of the present Political Constitution of the Germanic Empire*, Vol. II. p. 6.; and the Appendix to PENROSE's *Bampton Lectures.*

[3] I have said, *the decline of this heresy;* for it was by no means *immediately* extirpated even in the reformed churches. "As late as the year 1598, Daniel Hofman, Professor of Divinity in the University of Helmstadt, laying hold of some particular opinions of Luther, extravagantly maintained that philosophy was the mortal enemy of religion; that truth was divisible into two branches, the one *philosophical* and the other *theological;* and that what was *true* in philosophy was *false* in theology."—MOSHEIM, Vol. IV. p. 18.

In the meantime, a powerful obstacle to the progress of practical morality and of sound policy, was superadded to those previously existing in Catholic countries, by the rapid growth and extensive influence of the Machiavelian school. The founder of this new sect, or, to speak more correctly, the systematizer and apostle of its doctrines, was born as early as 1469, that is, about ten years before Luther; and, like that reformer, acquired, by the commanding superiority of his genius, an astonishing ascendant, though of a very different nature, over the minds of his followers. No writer, certainly, either in ancient or in modern times, has ever united, in a more remarkable degree, a greater variety of the most dissimilar and seemingly the most discordant gifts and attainments;—a profound acquaintance with all those arts of dissimulation and intrigue, which in the petty cabinets of Italy, were then universally confounded with political wisdom; an imagination familiarized to the cool contemplation of whatever is perfidious or atrocious in the history of conspirators and of tyrants; combined with a graphical skill in holding up to laughter the comparatively harmless follies of ordinary life. His dramatic humour has been often compared to that of Molière; but it resembles it rather in comic force, than in benevolent gaiety or in chastened morality. Such as it is, however, it forms an extraordinary contrast to that strength of intellectual character, which, in one page, reminds us of the deep sense of Tacitus, and in the next, of the dark and infernal policy of Cæsar Borgia. To all this must be supperadded a purity of taste, which has enabled him, as an historian, to rival the severe simplicity of the Grecian masters; and a sagacity in combining historical facts, which was afterwards to afford lights to the school of Montesquieu.

Eminent, however, as the talents of Machiavel unquestionably were, he cannot be numbered among the benefactors of mankind. In none of his writings does he exhibit any marks of that lively sympathy with the fortunes of the human race, or of that warm zeal for the interests of truth and justice, without the guidance of which, the highest mental endowments, when applied to moral or to political researches, are in perpetual danger of mistaking their way. What is still more remarkable, he seems to have been altogether blind to the mighty changes in human affairs, which, in consequence of the recent invention of printing, were about to result from the progress of Reason and the diffusion of Knowledge. Through the whole of his *Prince* (the most noted as well as one of the latest of his publications) he proceeds on the supposition, that the sovereign has no other object in governing, but his own advantage; the very circumstance which, in the judgment of Aristotle, constitutes the essence of the worst species of tyranny.[1] He assumes also the possibility of retaining mankind in perpetual bondage by the old policy of the *double doctrine;* or, in other words, by enlightening the few, and hoodwinking the many;—a policy less or more practised by statesmen in all ages and countries; but which, wherever the freedom of the press is respected, cannot fail, by the insult it offers to the discernment of the multitude, to increase the insecurity of those who have the weakness to employ it. It has been contended, indeed, by some of Machiavel's apologists, that his real object in unfolding and systematising the mysteries of *King-Craft*, was to point out indirectly to the governed the means by which the encroachments of their rulers might be most effectually resisted; and, at the same time, to satirize, under the ironical mask of loyal and courtly admonition, the characteristical vices of princes.[2] But, although this hypothesis has been sanctioned by several distinguished names, and derives some verisimilitude from various incidents in the author's life, it will be found, on examination, quite untenable; and accordingly it is now, I believe, very generally rejected. One thing is certain, that if such were actually

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[1] "There is a third kind of tyranny, which most properly deserves that odious name, and which stands in direct opposition to royalty; it takes place when one man, the worst perhaps and basest in the country, governs a kingdom with no other view than the advantage of himself and his family."—ARISTOTLE's *Politics*, Book vi. chap. x. See Dr GILLIES's Translation.

[2] See Note C.

Machiavel's views, they were much too refined for the capacity of his royal pupils. By many of these his book has been adopted as a manual for daily use; but I have never heard of a single instance, in which it has been regarded by this class of students as a disguised panegyric upon liberty and virtue. The question concerning the *motives* of the author is surely of little moment, when experience has enabled us to pronounce so decidedly on the practical *effects* of his precepts.

“About the period of the Reformation,” says Condorcet, “the principles of religious Machiavelism had become the *only* creed of princes, of ministers, and of pontiffs; and the same opinions had contributed to corrupt philosophy. What code, indeed, of morals,” he adds, “was to be expected from a system, of which one of the principles is,—that it is necessary to support the morality of the people by false pretences, and that men of enlightened minds have a right to retain others in the chains from which they have themselves contrived to escape!” The fact is perhaps stated in terms somewhat too unqualified; but there are the best reasons for believing that the exceptions were few, when compared with the general proposition.

The consequences of the prevalence of such a creed among the rulers of mankind were such as might be expected. “Infamous crimes, assassinations, and poisonings (says a French historian), prevailed more than ever. They were thought to be the growth of Italy, where the rage and weakness of the opposite factions conspired to multiply them. Morality gradually disappeared, and with it all security in the intercourse of life. The first principles of duty were obliterated by the joint influence of atheism and of superstition.”[1]

And here, may I be permitted to caution my readers against the common error of confounding the double doctrine of Machiavelian politicians, with the benevolent reverence for established opinions, manifested in the noted maxim of Fontenelle,—“that a wise man, even when his hand was full of truths, would often content himself with opening his little finger.” Of the advocates for the former, it may be justly said, that “they love darkness rather than light, *because their deeds are evil*;” well knowing, if I may borrow the words of Bacon, “that the open day-light doth not show the masks and mummeries, and triumphs of the world, half so stately as candle-light.” The philosopher, on the other hand, who is duly impressed with the latter, may be compared to the oculist, who, after removing the cataract of his patient, prepares the still irritable eye, by the glimmering dawn of a darkened apartment, for enjoying in safety the light of day.[2]

Machiavel is well known to have been, at bottom, no friend to the priesthood; and his character has been stigmatized by many of the order with the most opprobrious epithets. It is nevertheless certain, that to *his* maxims the royal defenders of the Catholic faith have been indebted for the spirit of that policy which they have uniformly opposed to the innovations of the Reformers. The *Prince* was a favourite book of the Emperor Charles V.; and was called the *Bible* of Catharine of Medicis. At the court of the latter, while Regent of France, those who approached her are said to have professed openly its most atrocious maxims; particularly *that* which recommends to sovereigns not to commit crimes by halves. The Italian cardinals, who are supposed to have been the secret instigators of the massacre of St Bartholomew, were bred in the same school.[1]

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[1] Millot.

[2] How strange is the following misrepresentation of Fontenelle's fine and deep saying, by the comparatively coarse hand of the Baron de Grimm! “Il disoit, que s'il êut tenu la vérité dans ses mains comme un oiseau, il l'auroit étouffée, tant il regardoit le plus beau présent du ciel inutile et dangereux pour le genre humain.”—(*Mémoires Historiques*, &c. par le BARON DE GRIMM. Londres, 1814. Tome I. p. 340.) Of the complete inconsistency of this statement, not only with the testimony of his most authentic biographers, but with the general tenor both of his life and writings, a judgment may be formed from an expression of D'Alembert, in his very ingenious and philosophical parallel between Fontenelle and La Motte. “Tous deux ont porté trop loin leur revolte décidée, quoique douce en apparence, contre les dieux et les lois du Parnasse; mais la liberté des opinions de la Motte semble tenir plus intimement à l'intérêt personnel qu'il avoit de les soutenir; et la liberté des opinions de Fontenelle *à l'intérêt général, peut-être quelquefois mal entendu, qu'il prenoit au progrès de la raison dans tous les genres.* What follows may be regarded in the light of a comment on the maxim above quoted: “La finesse de la Motte est plus développée, celle de Fontenelle laisse plus à deviner à son lecteur. La Motte, sans jamais en trop dire, n'oublie de ce que son sujet lui présente, met habilement tout en œuvre, et semble craindre perdre par des réticences trop subtiles quelqu'un de ses avantages; Fontenelle, sans jamais être obscur, excepté pour ceux qui ne meritent pas même qu'on soit clair, se ménage à la fois et le plaisir de sous-entendre, et celui d'espérer qu'il sera pleinement entendu par ceux qui en sont dignes.”—*Eloge de la Motte.*

It is observed by Mr Hume, that "there is scarcely any maxim in the *Prince*, which subsequent experience has not entirely refuted." "Machiavel," says the same writer, "was certainly a great genius; but having confined his study to the furious and tyrannical governments of ancient times, or to the little disorderly principalities of Italy, his reasonings, especially upon monarchical governments, have been found extremely defective. The errors of this politician proceeded, in a great measure, from his having lived in too early an age of the world, to be a good judge of political truth."[2]

To these very judicious remarks, it may be added, that the bent of Machiavel's mind seems to have disposed him much more strongly to combine and to generalize his historical reading, than to remount to the first principles of political science, in the constitution of human nature, and in the immutable truths of morality. His conclusions, accordingly, ingenious and refined as they commonly are, amount to little more (with a few very splendid exceptions) than empirical results from the events of past ages. To the student of ancient history they may be often both interesting and instructive; but, to the modern politician, the most important lesson they afford is, the danger, in the present circumstances of the world, of trusting to such results, as maxims of universal application, or of permanent utility.

The progress of political philosophy, and along with it of morality and good order, in every part of Europe, since the period of which I am now speaking, forms so pleasing a comment on the profligate and short-sighted policy of Machiavel, that I cannot help pausing for a moment to remark the fact. In stating it, I shall avail myself of the words of the same profound writer, whose strictures on Machiavel's *Prince* I had already occasion to quote. "Though all kinds of government," says Mr Hume, "be improved in modern times, yet monarchical government seems to have made the greatest advances towards perfection. It may now be affirmed of civilized monarchies, what was formerly said of republics alone, that they are a government of laws, not of men. They are found susceptible of order, method, and constancy, to a surprising degree. Property is there secure, industry encouraged, the arts flourish, and the prince lives secure among his subjects, like a father among his children. There are, perhaps, and have been for two centuries, near two hundred absolute princes, great and small, in Europe; and allowing twenty years to each reign, we may suppose that there have been in the whole two thousand monarchs, or *tyrants*, as the Greeks would have called them. Yet of these there has not been one, not even Philip II. of Spain, so bad as Tiberius, Caligula, Nero, or Domitian, who were four in twelve among the Roman Emperors."[3]

For this very remarkable fact, it seems difficult to assign any cause equal to the effect, but the increased diffusion of knowledge (imperfect, alas! as this diffusion still is) by means of the Press; which, while it has raised, in free states, a growing bulwark against the oppression of rulers, in the light and spirit of the people, has, even under the most absolute governments, had a powerful influence—by teaching princes to regard the wealth and prosperity and instruction of their subjects as the firmest basis of their grandeur—in directing their attention to objects of national and permanent utility. How encouraging the prospect thus opened of the future history of the world! And what a motive to animate the ambition of those, who, in the solitude of the closet, aspire to bequeath their contributions, how slender soever, to the progressive mass of human improvement and happiness!

In the bright constellation of scholars, historians, artists, and wits, who shed so strong a lustre on Italy during that splendid period of its history which commences with the revival of letters, it is surprising how few names occur, which it is possible to connect, by any palpable link, with the philosophical or political speculations of the present times. As an original and profound thinker, the genius of Machiavel completely eclipses that of all his contemporaries. Not that Italy was then destitute of writers who pretended to the character of philosophers; but as their attempts were, in general, limited to the exclusive illustration and defence of some one or other of the ancient systems for which they had conceived a predilection, they added but little of their own to the stock of useful knowledge, and are now remembered chiefly from the occasional recurrence of their names in the catalogues of the curious, or in the works of philological erudition. The zeal of Cardinal Bessarion, and of Marsilius Ficinus, for the revival of the Platonic philosophy, was more peculiarly remarkable, and, at one time, produced so general an impression, as to alarm the followers of Aristotle for the tottering authority of their master. If we may credit Launoius, this great revolution was on the point of being actually accomplished, when Cardinal Bellarmine warned Pope Clement VIII. of the peculiar danger of showing any favour to a philosopher whose opinions approached so nearly as those of Plato to the truths revealed in the Gospel. In what manner Bellarmine connected his conclusions with his premises, we are not informed. To those who are uninitiated in the mysteries of the conclave, his inference would certainly appear much less logical than that of the old Roman Pagans, who petitioned the Senate to condemn the works of Cicero to the flames, as they predisposed the minds of those who read them for embracing the Christian faith.

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[1] Voltaire, *Essay on Universal History.*

[2] *Essay on Civil Liberty.*

[3] *Ibid.*

By a small band of bolder innovators belonging to this golden age of Italian literature, the Aristotelian doctrines were more directly and powerfully assailed. Laurentius Valla, Marius Nizolius, and Franciscus Patricius,[1] have all of them transmitted their names to posterity as philosophical reformers, and, in particular, as revolters against the authority of the Stagirite. Of the individuals just mentioned, Nizolius is the only one who seems entitled to maintain a permanent place in the annals of modern science. His principal work, entitled *Antibarbarus*,[2] is not only a bold invective against the prevailing ignorance and barbarism of the schools, but contains so able an argument against the then fashionable doctrine of the Realists concerning *general ideas*, that Leibnitz thought it worth while, a century afterwards, to republish it, with the addition of a long and valuable preface written by himself.

At the same period with Franciscus Patricius, flourished another learned Italian, Albericus Gentilis, whose writings seem to have attracted more notice in England and Germany than in his own country. His attachment to the reformed faith having driven him from Italy, he sought an asylum at Oxford, where, in 1587, he was appointed professor of the Civil Law, an office which he held till the period of his death in 1611.[3] He was the author of a treatise *De Jure Belli*, in three books, which appeared successively in 1588 and 1589, and were first published together at Hanau in 1598. His name, however, has already sunk into almost total oblivion; and I should certainly not have mentioned it on the present occasion, were it not for his indisputable merits as the precursor of Grotius, in a department of study which, forty years afterwards, the celebrated treatise *De Jure Belli et Pacis* was to raise to so conspicuous a rank among the branches of academical education. The avowed aim of this new science, when combined with the anxiety of Gentilis to counteract the effect of Machiavel's *Prince*, by representing it as a warning to subjects rather than as a manual of instruction for their rulers, may be regarded as satisfactory evidence of the growing influence, even at that era, of better ethical principles than those commonly imputed to the Florentine Secretary.[1]

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[1] His *Discussiones Peripateticæ* were printed at Venice in 1571. Another work, entitled *Nova de Universis Philosophia*, also printed at Venice, appeared in 1593. I have never happened to meet with either; but from the account given of the author by Thuanus, he does not seem to have attracted that notice from his contemporaries, to which his learning and talents entitled him.—(Thuan. *Hist.* Lib. cxix. xvii.). His *Discussiones Peripateticæ* are mentioned by Brucker in the following terms:—"*Opus egregium, doctum, varium, luculentum, sed invidia odioque in Aristotelem plenum satis superque.*"—(*Hist. Phil.* Tom. IV. p. 425). The same very laborious and candid writer acknowledges the assistance he had derived from *Patricius* in his account of the Peripatetic philosophy.—"In qua tractatione fatemur egregiam enitere Patricii doctrinam, ingenii elegantiam prorsus admirabilem, et quod primo loco ponendum est, insolitam veteris philosophiæ cognitionem, cujus ope nos Peripateticæ disciplinæ historiæ multoties lucem attulisse, grati suis locis professi sumus."—*Ibid.* p. 426.

[2] *Antibarbarus, sive de Veris Principiis et Vera Ratione Philosophandi contra Pseudo-philosophos.* Parmæ, 1553. "Les faux philosophes," dit Fontenelle, "étoient tous les scholastiques passés et présens; et Nizolius s'élève avec la dernière hardièsse contre leurs idées monstrueuses et leur langage barbare. La longue et constante admiration qu'on avoit eu pour Aristote, ne prouvoit, disoit-il, que la multitude des sots et la durée de la sottise." The merits of this writer are much too lightly estimated by Brucker.—See *Hist. Phil.* Tom. IV. Pars I. pp. 91. 92.

[3] Wood's *Athenæ Oxonienses*, Vol. II. col. 90. Dr Bliss's edition.

The only other Italian of whom I shall take notice at present, is Campanella;[2] a philosopher now remembered chiefly in consequence of his eccentric character and eventful life, but of whom Leibnitz has spoken in terms of such high admiration, as to place him in the same line with Bacon. After looking into several of his works with some attention, I must confess I am at a loss to conceive upon what grounds the eulogy of Leibnitz proceeds; but as it is difficult to suppose, that the praise of this great man was, in any instance, the result of mere caprice, I shall put it in the power of my readers to judge for themselves, by subjoining a faithful translation of his words. I do this the more willingly, as the passage itself (whatever may be thought of the critical judgments pronounced in it), contains some general remarks on *intellectual character*, which are in every respect worthy of the author.

"Some men, in conducting operations where an attention to minutiæ is requisite, discover a mind vigorous, subtile, and versatile, and seem to be equal to any undertaking, how arduous soever. But when they are called upon to act on a greater scale, they hesitate and are lost in their own meditations; distrustful of their judgment, and conscious of their incompetency to the scene in which they are placed: men, in a word, possessed of a genius rather acute than comprehensive. A similar difference may be traced among authors. What can be more acute than Descartes in Physics, or than Hobbes in Morals! And yet, if the one be compared with Bacon, and the other with Campanella, the former writers seem to grovel upon the earth,—the latter to soar to the Heavens, by the vastness of their conceptions, their plans, and their enterprises, and to aim at objects beyond the reach of the human powers. The former, accordingly, are best fitted for delivering the first elements of knowledge, the latter for establishing conclusions of important and general application."[3]

The annals of France, during this period, present very scanty materials for the History of Philosophy. The name of the Chancellor de l'Hopital, however, must not be passed over in silence. As an author, he does not rank high; nor does he seem to have at all valued himself on the careless effusions of his literary hours; but, as an upright and virtuous magistrate, he has left behind him a reputation unrivalled to this day.[4] His wise and indulgent principles on the subject of religious liberty, and the steadiness with which he adhered to them, under circumstances of extraordinary difficulty and danger, exhibit a splendid contrast to the cruel intolerance, which, a few years before, had disgraced the character of an illustrious Chancellor of England. The same philosophical and truly catholic spirit distinguished his friend, the President de Thou,[1] and gives the principal charm to the justly admired preface prefixed to his history. In tracing the progress of the human mind during the sixteenth century, such insulated and anomalous examples of the triumph of reason over superstition and bigotry, deserve attention, not less than what is due, in a history of the experimental arts, to Friar Bacon's early anticipation of gunpowder, and of the telescope.

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[1] The claims of Albericus Gentilis to be regarded as the father of *Natural Jurisprudence*, are strongly asserted by his countryman Lampredi, in his very judicious and elegant work, entitled, *Juris Publici Theoremata*, published at Pisa in 1782. "Hic primus jus aliquod Belli et esse et tradi posse excogitavit, et Belli et Pacis regulas explanavit primus, et fortasse in causa fuit cur Grotius opus suum conscribere aggrederetur: dignus sane qui præ ceteris memoretur, Italiæ enim, in qua ortus erat, et unde Juris Romani disciplinam hauserat, gloriam auxit, effecitque ut quæ fuerat bonarum artium omnium restitutrix et altrix, eadem esset et prima Jurisprudentiæ Naturalis magistra."

[2] Born 1568, died 1639.

[3] Leibnit. *Opera*, Vol. VI. p. 303, ed. Dutens.—It is probable that, in the above passage, Leibnitz alluded more to the elevated tone of Campanella's reasoning on moral and political subjects, when contrasted with that of Hobbes, than to the intellectual superiority of the former writer above the latter. No philosopher, certainly, has spoken with more reverence than Campanella has done, on various occasions, of the dignity of human nature. A remarkable instance of this occurs in his eloquent comparison of the *human hand* with the organs of touch in other animals. (*Vide* Campan. *Physiolog.* cap. xx. Art. 2.) Of his *Political Aphorisms*, which form the third part of his treatise on *Morals*, a sufficient idea for our purpose is conveyed by the concluding *corollary*, "Probitas custodit regem populosque; non autem indocta Machiavellistarum astutia." On the other hand, Campanella's works abound with immoralities and extravagancies far exceeding those of Hobbes. In his idea of a perfect commonwealth (to which he gives the name of *Civitas Solis*), the impurity of his imagination, and the unsoundness of his judgment, are equally conspicuous. He recommends, under certain regulations, a community of women; and, in every thing connected with procreation, lays great stress on the opinions of astrologers.

[4] Magistrat au-dessus de tout eloge; et d'après lequel on a jugé tous ceux qui ont osé s'asseoir sur ce même tribunal sans avoir son courage ni ses lumières."—Henault, *Abrégé Chronologique.*

Contemporary with these great men was Bodin (or Bodinus),[2] an eminent French lawyer, who appears to have been one of the first that united a philosophical turn of thinking with an extensive knowledge of jurisprudence and of history. His learning is often ill digested, and his conclusions still oftener rash and unsound; yet it is but justice to him to acknowledge, that, in his views of the philosophy of law, he has approached very nearly to some leading ideas of Lord Bacon;[3] while, in his refined combinations of historical facts, he has more than once struck into a train of speculation, bearing a strong resemblance to that afterwards pursued by Montesquieu.[4] Of this resemblance, so remarkable an instance occurs in his chapter on the moral effects of Climate, and on the attention due to this circumstance by the legislator, that it has repeatedly subjected the author of *The Spirit of Laws* (but in my opinion without any good reason) to the imputation of plagiarism.[5] A resemblance to Montesquieu, still more honourable to Bodinus, may be traced in their common attachment to religious as well as to civil liberty. To have caught, in the sixteenth century, somewhat of the philosophical spirit of the eighteenth, reflects less credit on the force of his mind, than to have imbibed, in the midst of the theological controversies of his age, those lessons of mutual forbearance and charity, which a long and sad experience of the fatal effects of persecution has to this day so imperfectly taught to the most enlightened nations of Europe.

As a specimen of the liberal and moderate views of this philosophical politician, I shall quote two short passages from his Treatise *De la République*, which seem to me objects of considerable curiosity, when contrasted with the general spirit of the age in which they were written. The first relates to liberty of conscience, for which he was a strenuous and intrepid advocate, not only in his publications, but as a member of the *Etats Généraux*, assembled at Blois in 1576. "The mightier that a man is (says Bodin), the more justly and temperately he ought to behave himself towards all men, but especially towards his subjects. Wherefore the senate and people of Basil did wisely, who, having renounced the Bishop of Rome's religion, would not, upon the sudden, thrust the monks and nuns, with the other religious persons, out of their abbeys and monasteries, but only took order, that, as they died they should die both for themselves and their successors, expressly forbidding any new to be chosen in their places, so that, by that means, their colleges might, by little and little, by the death of the fellows, be extinguished. Whereby it came to pass, that all the rest of the Carthusians, of their own accord, forsaking their cloisters, yet one of them all alone for a long time remained therein, quietly and without any disturbance, holding the right of his convent, being never enforced to change either his place, or habit, or old ceremonies, or religion before by him received. The like order was taken at Coire in the diet of the Grisons; wherein it was decreed, that the ministers of the reformed religion should be maintained of the profits and revenues of the church, the religious men nevertheless still remaining in their cloisters and convents, to be by their death suppressed, they being now prohibited to choose any new instead of them which died. By which means, they which professed the new religion, and they who professed the old, were both provided for."[1]

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[1] "One cannot help admiring," says Dr Jortin, "the *decent* manner in which the illustrious Thuanus hath spoken of Calvin:" "Acri vir ac vehementi ingenio, et admirabili facundia præditus; tum inter protestantes magni nominis theologus."—*(Life of Erasmus*, p. 555.) The same writer has remarked the *great decency and moderation* with which Thuanus speaks of Luther.—*Ibid.* p. 113.

[2] Born 1530, died 1596.

[3] See, in particular, the preface to his book, entitled *Methodus ad facilem Historiarum cognitionem.*

[4] See the work *De la République, passim.* In this treatise there are two chapters singularly curious, considering the time when they were written; the second and third chapters of the sixth book. The first is entitled, *Des Finances;* the second, *Le Moyen d'empêcher que les Monnoyes soyent alterées de Prix ou falsifiées.* The reasonings of the Author on various points there treated of, will be apt to excite a smile among those who have studied the *Inquiry into the Wealth of Nations;* but it reflects no small credit on a lawyer of the sixteenth century to have subjected such questions to philosophical examination, and to have formed so just a conception as Bodin appears evidently to have done, not only of the object, but of the importance of the modern science of political economy.

Thuanus speaks highly of Bodin's dissertations *De Re Monetaria*, which I have never seen. The same historian thus expresses himself with respect to the work *De Republica:* "Opus in quo ut omni scientiarum genere non tincti sed imbuti ingenii fidem fecit, sic nonnullis, qui recte judicant, non omnino ab *ostentationis innato genti vitio* vacuum se probavit.—*Hist.* Lib. cxvii. ix.

[5] See Note D.

The aim of the chapter from which I have extracted the foregoing passage, is to show, that "it is a most dangerous thing, at one and the same time, to change the form, laws, and customs of a commonwealth." The scope of the author's reasonings may be judged of from the concluding paragraph.

"We ought then in the government of a well-ordered state and commonwealth, to imitate and follow the great God of Nature, who in all things proceedeth easily, and by little and little; who of a little seed causeth to grow a tree for height and greatness, right admirable, and yet for all that insensibly; and still by means conjoining the extremities of nature, as by putting the spring between winter and summer, and autumn betwixt summer and winter, moderating the extremities of the terms and seasons, with the self-same wisdom which it useth in all other things also, and that in such sort, as that no violent force or course therein appeareth."[2]

Notwithstanding these wise and enlightened maxims, it must be owned, on the other hand, that Bodin has indulged himself in various speculations, which would expose a writer of the present times to the imputation of insanity. One of the most extraordinary of these, is his elaborate argument to prove, that, in a well constituted state, the father should possess the right of life and death over his children;—a paradox which forms an unaccountable contrast to the general tone of humanity which characterizes his opinions. Of the extent of his credulity on the subject of witchcraft, and of the deep horror with which he regarded those who affected to be sceptical about the reality of that crime, he has left a lasting memorial in a learned and curious volume entitled *Démonomanie*;[3] while the ce-

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[1] Book iv. chap. iii.—The book from which this quotation is taken was published only twenty-three years after the murder of Servetus at Geneva; an event which leaves so deep a stain on the memory not only of Calvin, but on that of the milder and more charitable Melanchthon. The epistle of the latter to Bullinger, where he applauds the conduct of the judges who condemned to the flames this incorrigible heretic, affords the most decisive of all proofs, how remote the sentiments of the most enlightened Fathers of the Reformation were from those Christian and philosophical principles of toleration, to which their noble exertions have gradually, and now almost universally, led the way.

[2] *Ibid.*—The substance of the above reflection has been compressed by Bacon into the following well-known aphorisms.

"Time is the greatest innovator; shall we then not imitate time?

"What innovator imitates time, which innovates so silently as to mock the sense?"

The resemblance between the two passages is still more striking in the Latin versions of their respective authors.

"Deum igitur præpotentem naturæ parentem imitemur, qui omnia paulatim: namque semina perquam exigua in arbores excelsas excrescere jubet, idque tam occulte ut nemo sentiat."—BODINUS.

"Novator maximus tempus; quidni igitur tempus imitemur?"

"Quis novator tempus imitatur, quod novationes ita insinuat, ut sensus fallant?"—BACON.

The Treatise of Bodin *De la République* (by far the most important of his works) was first printed at Paris in 1576, and was reprinted seven times in the space of three years. It was translated into Latin by the author himself, with a view chiefly (as is said) to the accommodation of the scholars of England, among whom it was so highly esteemed, that lectures upon it were given in the University of Cambridge, as early as 1580. In 1579, Bodin visited London in the *suite* of the Duc d'Alençon; a circumstance which probably contributed not a little to recommend his writings, so very soon after their publication, to the attention of our countrymen. In 1606, the treatise of *The Republic* was *done into English* by Richard Knolles, who appears to have collated the French and Latin copies so carefully and judiciously, that his version is, in some respects, superior to either of the originals. It is from this version, accordingly, that I have transcribed the passages above quoted; trusting, that it will not be unacceptable to my readers, while looking back to the intellectual attainments of our forefathers, to have an opportunity, at the same time, of marking the progress which had been made in England, more than two centuries ago, in the arts of writing and of translation.

For Dr Johnson's opinion of Knolles's merits as an historian, and as an English writer, see *the Rambler*, No. 123.

[3] *De la Démonomanie des Sorciers.* Par J. BODIN ANGEVIN, à Paris, 1580. This book, which exhibits so melancholy

centricity of his religious tenets was such, as to incline the candid mind of Grotius to suspect him of a secret leaning to the Jewish faith.[1]

In contemplating the characters of the eminent persons who appeared about this era, nothing is more interesting and instructive, than to remark the astonishing combination, in the same minds, of the highest intellectual endowments, with the most deplorable aberrations of the understanding; and even, in numberless instances, with the most childish superstitions of the multitude. Of this apparent inconsistency, Bodinus does not furnish a solitary example. The same remark may be extended, in a greater or less degree, to most of the other celebrated names hitherto mentioned. Melanchthon, as appears from his letters, was an interpreter of dreams, and a caster of nativities;[2] and Luther not only sanctioned, by his authority, the popular fables about the sexual and prolific intercourse of Satan with the human race, but seems to have seriously believed that he had himself frequently seen the *arch enemy* face to face, and held arguments with him on points of theology.[3] Nor was the study of the severer sciences, on all occasions, an effectual remedy against such illusions of the imagination. The *sagacious* Kepler was an astrologer and a visionary; and his friend Tycho Brahe, *the Prince of Astronomers*, kept an idiot in his service, to whose prophecies he listened as revelations from above.[4] During the long night of Gothic barbarism, the intellectual world had again become, like the primitive earth, "without form and void;" the light had already appeared; "and God had seen the light that it was good;" but the time was not yet come to "divide it from the darkness."[5]

In the midst of the disorders, both political and moral, of that unfortunate age, it is pleasing to observe the anticipations of brighter prospects, in the speculations of a few individuals. Bodinus himself is one of the number;[6] and to his name may be added that of his countryman and predecessor Budæus.[7] But, of all the writers of the sixteenth century, Ludovicus Vives seems to have had the liveliest and the

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a contrast to the mental powers displayed in the treatise *De la République*, was dedicated by the author to his friend, the President de Thou; and it is somewhat amusing to find, that it exposed Bodin himself to the imputation of being a magician. For this we have the testimony of the illustrious historian just mentioned.—(THUANUS, Lib. cxvii. ix.)—Nor did it recommend the author to the good opinion of the Catholic church, having been formally condemned and prohibited by the Roman Inquisition. The Reflection of the Jesuit Martin del Rio on this occasion is worth transcribing. "*Adeo lubricum et periculosum de his disscrere, nisi Deum semper, et catholicam fidem, ecclesiæque Romanæ censuram tanquam cynosuram sequaris.*"—*Disquisitionum Magicarum*, Libri Sex. Auctore MARTINO DEL RIO, Societatis Jesu Presbytero. Venit. 1640, p. 8.

[1] *Epist. ad Cordesium* (quoted by BAYLE.)

[2] JORTIN's *Life of Erasmus*, p. 156.

[3] See Note E.

[4] See *the Life of Tycho Brahe*, by GASSENDI.

[5] I have allotted to Bodin a larger space than may seem due to his literary importance; but the truth is, I know of no political writer, of the same date, whose extensive and various and discriminating reading appears to me to have contributed more to facilitate and to guide the researches of his successors, or whose references to ancient learning have been more frequently transcribed without acknowledgment. Of late his works have fallen into very general neglect; otherwise it is impossible that so many gross mistakes should be current about the scope and spirit of his principles. By many he has been mentioned as a zealot for republican forms of government, probably for no better reason than that he chose to call his book a Treatise *De Republica;* whereas, in point of fact, he is uniformly a warm and able advocate for monarchy; and, although no friend to tyranny, has, on more than one occasion, carried his monarchical principles to a very blameable excess.—(See, in particular, chapters fourth and fifth of the Sixth Book.) On the other hand, Grouvelle, a writer of some note, has classed Bodin with Aristotle, as an advocate for domestic slavery. "The reasonings of both," he says, "are refuted by Montesquieu."—*(De l'Autorité de Montesquieu dans la Révolution présente.* Paris, 1789.) Whoever has the curiosity to compare Bodin and Montesquieu together, will be satisfied, that, on this point, their sentiments were exactly the same; and that, so far from refuting Bodin, Montesquieu has borrowed from him more than one argument in support of his general conclusion.

The merits of Bodin have been, on the whole, very fairly estimated by Bayle, who pronounces him "one of the ablest men that appeared in France during the sixteenth century." "Si nous voulons disputer à Jean Bodin la qualité d'écrivain éxact et judicieux, laissons lui sans controverse, un grand génie, un vaste savoir, une mémoire et une lecture prodigieuses.

[6] See, in particular, his *Method of Studying History*, chap. vii. entitled *Confutatio eorum qui quatuor Monarchias Aureaque Sæcula statuerunt.* In this chapter, after enumerating some of the most important discoveries and inventions of the moderns, he concludes with mentioning the art of printing, of the value of which he seems to have formed a very just estimate. "Una Typographia cum omnibus veterum inventis certare facile potest. Itaque non minus peccant, qui a veteribus aiunt omnia comprehensa, quam qui illos de veteri multarum artium possessione deturbant. Habet Natura scientiarum thesauros innumerabiles, qui nullis ætatibus exhauriri possunt." In the same chapter Bodinus expresses himself thus: "Ætas illa quam *auream* vocant, si ad nostram conferatur, *ferrea* videri possit."

[7] The works of Budæus were printed at Basle, in four volumes folio, 1557. My acquaintance with them is much too slight to enable me to speak of them from my own judgment. No scholar certainly stood higher in the estimation of his age. "Quo viro," says Ludovicus Vives, "Gallia acutiore ingenio, acriroe judicio, exactiore diligentia, majore eruditione nullum unquam produxit; hac vero ætate nec Italia quidem." The praise bestowed on him by other contemporary writers of the highest eminence is equally lavish.

most assured foresight of the new career on which the human mind was about to enter. The following passage from one of his works would have done no discredit to the *Novum Organon*:—"The similitude which many have fancied between the superiority of the moderns to the ancients, and the elevation of a dwarf on the back of a giant, is altogether false and puerile. Neither were *they* giants, nor are we dwarfs, but all of us men of the same standard,—and *we* the taller of the two, by adding their height to our own: Provided always that we do not yield to them in study, attention, vigilance, and love of truth; for, if these qualities be wanting, so far from mounting on the giant's shoulders, we throw away the advantages of our own just stature, by remaining prostrate on the ground."[1]

I pass over, without any particular notice, the names of some French logicians who flourished about this period, because, however celebrated among their contemporaries, they do not seem to form essential links in the History of Science. The bold and persevering spirit with which Ramus disputed, in the University of Paris, the authority of Aristotle, and the persecutions he incurred by this philosophical heresy, entitle him to an honourable distinction from the rest of his brethren. He was certainly a man of uncommon acuteness as well as eloquence, and placed in a very strong light some of the most vulnerable parts of the Aristotelian logic; without, however, exhibiting any marks of that deep sagacity which afterwards enabled Bacon, Descartes, and Locke, to strike at the very roots of the system. His copious and not inelegant style as a writer, recommended his innovations to those who were disgusted with the barbarism of the schools;[2] while his avowed partiality for the reformed faith (to which he fell a martyr in the massacre of Paris), procured many proselytes to his opinions in all the Protestant countries of Europe. In England his logic had the honour, in an age of comparative light and refinement, to find an expounder and methodiser in the author of Paradise Lost; and in some of our northern universities, where it was very early introduced, it maintained its ground till it was supplanted by the logic of Locke.

It has been justly said of Ramus, that, "although he had genius sufficient to shake the Aristotelian fabric, he was unable to substitute any thing more solid in its place;" but it ought not to be forgotten, that even *this* praise, scanty as it may now appear, involves a large tribute to his merits as a philosophical reformer. Before human reason was able to advance, it was necessary that it should first be released from the weight of its fetters.[3]

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[1] Vives *de Caus. Corrupt. Artium*, Lib. i. Similar ideas occur in the works of Roger Bacon: "Quanto juniores tanto perspicaciores, quia juniores posteriores successione temporum ingrediuntur labores priorum."—(*Opus Majus*, edit. Jebb. p. 9.) Nor were they altogether overlooked by ancient writers. "Veniet tempus, quo ista quæ latent nunc in lucem dies extrahet, et longioris ævi diligentia. Veniet tempus, quo posteri nostri tam aperta nos ignorasse mirabuntur." (Seneca, *Quæst. Nat.* Lib. vii. c. 25.) This language coincides exactly with that of the Chancellor Bacon; but it was reserved for the latter to illustrate the connection between the progress of human *knowledge*, and of human *happiness*; or (to borrow his own phraseology) the connection between the progress of knowledge, and the enlargement of man's *power* over the destiny of his own species. Among other passages to this purpose, See *Nov. Org.* Lib. i. cxxix.

[2] To the accomplishments of Ramus as a writer, a very flattering testimony is given by an eminent English scholar, by no means disposed to overrate his merits as a logician. "Pulsa tandem barbarie, Petrus Ramus politioris literaturæ vir, ausus est Aristotelem acrius ubique et liberius incessere, universamque Peripateticam philosophiam exagitare. Ejus *Dialctica* exiguo tempore fuit apud plurimos summo in pretio, maxime eloquentiæ studiosos, idque idio scholasticorum, quorum dictio et *stylus* ingrata fuerant auribus Ciceronianis."—*Logicæ Artis Compendium*, Auctore R. Sanderson, Episc. Lincoln, pp. 250. 251. Edit. Decima. Oxon. The first edition was printed in 1618.

[3] Dr Barrow, in one of his mathematical lectures, speaks of Ramus in terms far too contemptuous. "Homo, ne quid gravius dicam, *argutulus et dicaculus*."—"Sane vix indignationi meæ tempero, quin illum accipiam pro suo merito, regeramque validius in ejus caput, quæ contra veteres jactat convicia." Had Barrow confined this censure to the weak and arrogant attacks made by Ramus upon Euclid (particularly upon Euclid's definition of Proportion), it would not have been more than Ramus deserved; but it is evident he meant to extend it also to the more powerful attacks of the same reformer upon the logic of Aristotle. Of these there are many which may be read with profit even in the present times. I select one passage as a specimen, recommending it strongly to the consideration of those logicians who have lately stood forward as advocates for Aristotle's *abcccdarian* demonstrations of the syllogistic rules. "In Aristotelis arte, unius præcepti unicum exemplum est, ac sæpissime nullum: sed unico et singulari exemplo non potest artifex effici; pluribus opus est et dissimilibus. Et quidem, ut Aristotelis exempla tantummodo non falsa sint, qualia tamen sunt? Omne *b* est *a*: omne *c* est *b*: ergo omne *c* est *a*. Exemplum Aristotelis est puero a grammaticis et oratoribus venienti, et istam mutorum Mathematicorum linguam ignoranti, novum et durum: et in totis Analyticis ista non Attica, non Ionica, non Dorica, non Æolica, non communi, sed geometrica lingua usus est Aristoteles, odiosa pueris, ignota populo, a communi sensu remota, a rhetoricæ usu et ab humanitatis usu alienissima."—(P. Rami *pro Philosophica Parisiensis Academiæ Disciplina Oratio*, 1550). If these strictures should be thought too loose and declamatory, the reader may consult the fourth chapter *(De Conversionibus)* of the seventh book of Ramus's *Dialectics*, where the same charge is urged, in my opinion, with irresistible force of argument.

It is observed with great truth, by Condorcet, that, in the times of which we are now speaking, "the science of political economy did not exist. Princes estimated not the number of men, but of soldiers in the state;—finance was merely the art of plundering the people, without driving them to the desperation that might end in revolt;—and governments paid no other attention to commerce but that of loading it with taxes, of restricting it by privileges, or of disputing for its monopoly."

The internal disorders then agitating the whole of Christendom, were still less favourable to the growth of this science, considered as a branch of speculative study. Religious controversies everywhere divided the opinions of the multitude;—involving those collateral discussions concerning the liberty of conscience, and the relative claims of sovereigns and subjects, which, by threatening to resolve society into its first elements, present to restless and aspiring spirits the most inviting of all fields for enterprise and ambition. Amidst the shock of such discussions, the calm inquiries which meditate in silence the slow and gradual amelioration of the social order, were not likely to possess strong attractions, even to men of the most sanguine benevolence; and, accordingly, the political speculations of this period turn almost entirely on the comparative advantages and disadvantages of different forms of government, or on the still more alarming questions concerning the limits of allegiance and the right of resistance.

The dialogue of our illustrious countryman Buchanan, *De Jure Regni apud Scotos*, though occasionally disfigured by the keen and indignant temper of the writer, and by a predilection (pardonable in a scholar warm from the schools of ancient Greece and Rome) for forms of policy unsuitable to the circumstances of modern Europe, bears, nevertheless, in its general spirit, a closer resemblance to the political philosophy of the eighteenth century, than any composition which had previously appeared. The ethical paradoxes afterwards inculcated by Hobbes as the ground-work of his slavish theory of government, are anticipated and refuted, and a powerful argument is urged against that doctrine of Utility which has attracted so much notice in our times. The political reflections, too, incidentally introduced by the same author in his History of Scotland, bear marks of a mind worthy of a better age than fell to his lot. Of this kind are the remarks with which he closes his narrative of the wanton cruelties exercised in punishing the murderers of James the First. In reading them, one would almost imagine, that one is listening to the voice of Beccaria or of Montesquieu. "After this manner," says the historian, "was the cruel death of James still more cruelly avenged. For punishments so far exceeding the measure of humanity, have less effect in deterring the multitude from crimes, than in rousing them to greater efforts, both as actors and as sufferers. Nor do they tend so much to intimidate by their severity, as by their frequency to diminish the terrors of the spectators. The evil is more peculiarly great, when the mind of the criminal is hardened against the sense of pain; for in the judgment of the unthinking vulgar, a stubborn confidence generally obtains the praise of heroic constancy."

After the publication of this great work, the name of Scotland, so early distinguished over Europe by the learning and by the *fervid genius*[1] of her sons, disappears for more than a century and a half from the History of Letters. But from this subject, so pregnant with melancholy and humiliating recollections, our attention is forcibly drawn to a mighty and auspicious light which, in a more fortunate part of the island, was already beginning to rise on the philosophical world.[2]

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[1] Præfervidum Scotorum ingenium.

[2] That, at the end of the sixteenth century, the Scottish nation were advancing not less rapidly than their neighbours, in every species of mental cultivation, is sufficiently attested by their literary remains, both in the Latin language and in their own vernacular tongue. A remarkable testimony to the same purpose occurs in the dialogue above quoted, the author of which had spent the best years of his life in the most polished society of the Continent. "As often," says Buchanan, "as I turn my eyes to the niceness and elegance of our own times, the ancient manners of our forefathers appear sober and venerable, but withal rough and horrid."—"Quoties oculos ad nostri temporis munditias et elegantiam refero, antiquitas illa sancta et sobria, sed *horrida* tamen, et nondum *satis expolita* fuisse videtur."—(*De Jure Regni apud Scotos.*) One would think, that he conceived the taste of his countrymen to have then arrived at the *ne plus ultra* of national refinement,

Aurea nunc, olim sylvestribus *horrida* dumis.

CHAPTER II.

FROM THE PUBLICATION OF BACON'S PHILOSOPHICAL WORKS, TILL THAT OF THE ESSAY ON HUMAN UNDERSTANDING.

SECTION I.

Progress of Philosophy in England during this period.

BACON.[1]

The state of science towards the close of the sixteenth century, presented a field of observation singularly calculated to attract the curiosity, and to awaken the genius of Bacon; nor was it the least of his personal advantages, that, as the son of one of Queen Elizabeth's ministers, he had a ready access, wherever he went, to the most enlightened society in Europe. While yet only in the seventeenth year of his age, he was removed by his father from Cambridge to Paris, where it is not to be doubted, that the novelty of the literary scene must have largely contributed to cherish the natural liberality and independence of his mind. Sir Joshua Reynolds has remarked, in one of his academical Discourses, that "every seminary of learning is surrounded with an atmosphere of floating knowledge, where every mind may imbibe somewhat congenial to its own original conceptions."[2] He might have added, with still greater truth, that it is an atmosphere, of which it is more peculiarly salutary for those who have been elsewhere reared to breathe the air. The remark is applicable to higher pursuits than were in the contemplation of this philosophical artist; and it suggests a hint of no inconsiderable value for the education of youth.

The merits of Bacon, as the father of Experimental Philosophy, are so universally acknowledged, that it would be superfluous to touch upon them here. The lights which he has struck out in various branches of the Philosophy of Mind, have been much less attended to; although the whole scope and tenor of his speculations show, that to *this* study his genius was far more strongly and happily turned, than to that of the Material World. It was not, as some seem to have imagined, by sagacious anticipations of particular discoveries afterwards to be made in physics, that his writings have had so powerful an influence in accelerating the advancement of that science. In the extent and accuracy of his *physical* knowledge, he was far inferior to many of his predecessors; but he surpassed them all in his knowledge of the laws, the resources, and the limits of the human understanding. The sanguine expectations with which he looked forwards to the future, were founded solely on his confidence in the untried *capacities of the mind*, and on a conviction of the possibility of invigorating and guiding, by means of logical rules, those faculties which, in all our researches after truth, are the organs or instruments to be employed. "Such rules," as he himself has observed, "do in some sort equal men's wits, and leave no great advantage or pre-eminence to the perfect and excellent motions of the spirit. To draw a straight line, or to describe a circle, by aim of hand only, there must be a great difference between an unsteady and unpractised hand, and a steady and practised; but to do it by rule or compass it is much alike."

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[1] Born 1561, died 1626.

[2] Discourse delivered at the opening of the Royal Academy, January 2, 1769.

Nor is it merely as a logician that Bacon is entitled to notice on the present occasion. It would be difficult to name another writer prior to Locke, whose works are enriched with so many just observations on the intellectual phenomena. Among these, the most valuable relate to the laws of Memory, and of Imagination; the latter of which subjects he seems to have studied with peculiar care. In one short but beautiful paragraph concerning *Poetry* (under which title may be comprehended all the various creations of this faculty), he has exhausted every thing that philosophy and good sense have yet had to offer, on what has been since called the *Beau Ideal;* a topic, which has furnished occasion to so many over-refinements among the French critics, and to so much extravagance and mysticism in the *cloud-clapt* metaphysics of the new German school.[1] In considering imagination as connected with the nervous system, more particularly as connected with that species of sympathy to which medical writers have given the name of *imitation,* he has suggested some very important hints which none of his successors have hitherto prosecuted; and has, at the same time, left an example of cautious inquiry, worthy to be studied by all who may attempt to investigate the laws regulating the union between Mind and Body.[2] His illustration of the different classes of prejudices incident to human nature, is, in point of practical utility, at least equal to any thing on that head to be found in Locke, of whom it is impossible to forbear remarking, as a circumstance not easily explicable, that he should have resumed this important discussion, without once mentioning the name of his great predecessor. The chief improvement made by Locke, in the farther prosecution of the argument, is the application of Hobbes's theory of association, to explain in what manner these prejudices are originally generated.

In Bacon's scattered hints on topics connected with the Philosophy of the Mind, strictly so called, nothing is more remarkable than the precise and just ideas they display of the proper aim of this science. He had manifestly reflected much and successfully on the operations of his own understanding, and had studied with uncommon sagacity the intellectual characters of others. Of his reflections and observations on both subjects, he has recorded many important results, and has in general stated them without the slightest reference to any physiological theory concerning their causes, or to any analogical explanations founded on the caprices of metaphorical language. If, on some occasions, he assumes the existence of *animal spirits,* as the medium of communication between Soul and Body, it must be remembered, that this was *then* the universal belief of the learned; and that it was at a much later period not less confidently avowed by Locke. Nor ought it to be overlooked (I mention it to the credit of *both* authors), that in such instances the *fact* is commonly so stated, as to render it easy for the reader to detach it from the *theory*. As to the scholastic questions concerning the nature and essence of mind,—whether it be extended or unextended? whether it have any relation to space or to time? or whether (as was contended by others) it exist in *every ubi*, but in *no place?*—Bacon has uniformly passed them over with silent contempt; and has probably contributed not less effectually to bring them into general discredit, by this indirect intimation of his own opinion, than if he had descended to the ungrateful task of exposing their absurdity.[1]

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[1] "Cum mundus sensibilis sit anima rationali dignitate inferior, videtur *Poësis* hæc humanæ naturæ largiri quæ historia denegat; atque animo umbris rerum utcunque satisfacere, cum solida haberi non possint. Si quis enim rem acutius introspiciat, firmum ex *Poësi* sumitur argumentum, magnitudinem rerum magis illustrem, ordinem magis perfectum, et varietatem magis pulchram, animæ humanæ complacere, quam in natura ipsa, post lapsum; reperiri ullo modo possit. Quapropter, cum res gestæ et eventus, qui veræ historiæ subjiciuntur, non sint ejus amplitudinis, in qua anima humana sibi satisfaciat, præsto est *Poësis,* quæ facta magis heroica confingat. Cum historia vera successus rerum, minime pro meritis virtutum et scelerum narret, corrigit eam *Poësis,* et exitus, et fortunas, secundum merita, et ex lege Nemeseos, exhibet. Cum historia vera obvia rerum satietate et similitudine, animæ humanæ fastidio sit reficit eam *Poësis,* inexpectata, et varia, et vicissitudinum plena canens. Adeo ut *Poësis* ista non solum ad delectationem, sed ad animi magnitudinem, et ad mores conferat."—(*De Aug. Scient.* Lib. ii. cap. xiii.)

[2] To this branch of the philosophy of mind, Bacon gives the title of *Doctrina de fœdere, sive de communi vinculo animæ et corporis.*—(*De Aug. Scient.* Lib. iv. cap. i.) Under this article, he mentions, among other *desiderata,* an inquiry (which he recommends to physicians) concerning the influence of imagination over the body. His own words are very remarkable; more particularly, the clause in which he remarks the effect of fixing and concentrating the attention, in giving to ideal objects the power of realities over the belief. "Ad aliud quippiam, quod huc pertinet, parce admodum, nec pro rei subtilitate, vel utilitate, inquisitum est; quatenus scilicet *ipsa imaginatio animæ vel cogitatio perquam fixa, et veluti in fidem quandam exaltata.* valeat ad immutandum corpus imaginantis."—(*Ibid.*) He suggests also, as a curious problem, to ascertain how far it is possible to fortify and exalt the imagination; and by what means this may most effectually be done. The class of facts here alluded to, are manifestly of the same description with those to which the attention of philosophers has been lately called by the pretensions of Mesmer and of Perkins: "Atque huic conjuncta est disquisitio, quomodo imaginatio intendi et fortificari possit? Quippe, si imaginatio fortis tantarum sit virium, operæ pretium fuerit nôsse, quibus modis eam exaltari, et se ipsa majorem fieri detur? Atque hic oblique, nec minus periculose se insinuat palliatio quædam et defensio maximæ partis *Magiæ Ceremonialis,*" &c. &c.—*De Aug. Scient.* Lib. iv. cap. iii.

While Bacon, however, so cautiously avoids these unprofitable discussions about the nature of Mind, he decidedly states his conviction, that the *faculties* of Man differ not merely in degree, but in kind, from the instincts of the brutes. "I do not, therefore," he observes on one occasion, "approve of that confused and promiscuous method in which philosophers are accustomed to treat of pneumatology; as if the human Soul ranked above those of brutes, merely like the sun above the stars, or like gold above other metals."

Among the various topics started by Bacon for the consideration of future logicians, he did not overlook (what may be justly regarded, in a practical view, as the most interesting of all logical problems) the question concerning the mutual influence of Thought and of Language on each other. "Men believe," says he, "that their reason governs their words; but it often happens, that words have power enough to *react* upon reason." This aphorism may be considered as the text of by far the most valuable part of Locke's Essay,—*that* which relates to the imperfections and abuse of words; but it was not until within the last twenty years that its depth and importance were perceived in all their extent. I need scarcely say, that I allude to the excellent Memoirs of M. Prevost and of M. Degerando, on "Signs considered in their connection with the Intellectual Operations." The anticipations formed by Bacon, of that branch of modern logic which relates to *Universal Grammar*, do no less honour to his sagacity. "Grammar," he observes, "is of two kinds, the one literary, the other philosophical. The former has for its object to trace the analogies running through the structure of a particular tongue, so as to facilitate its acquisition to a foreigner, or to enable him to speak it with correctness and purity. The latter directs the attention, *not* to the analogies which words bear to words, but the analogies which words bear to things;"[2] or, as he afterwards explains himself more clearly, "to language considered as the sensible portraiture or image of the mental process." In farther illustration of these hints, he takes notice of the lights which the different genius of different languages reflect on the characters and habits of those by whom they were respectively spoken. "Thus," says he, "it is easy to perceive, that the Greeks were addicted to the culture of the arts, the Romans engrossed with the conduct of affairs; inasmuch as the technical distinctions introduced in the progress of refinement require the aid of compounded words; while the real business of life stands in no need of so artificial a phraseology."[3] Ideas of this sort have, in the course of a very few years, already become common, and almost tritical; but how different was the case two centuries ago!

With these sound and enlarged views concerning the philosophy of the Mind, it will not appear surprising to those who have attended to the slow and irregular advances of human reason, that Bacon should occasionally blend incidental remarks, savouring of the habits of thinking prevalent in his time. A curious example of this occurs in the same chapter which contains his excellent definition or description of universal grammar. "This too," he observes, "is worthy of notice, that the ancient languages were full of declensions, of cases, of conjugations, of tenses, and of other similar inflections; while the modern, almost entirely destitute of these, indolently accomplish the same purpose by the help of prepositions, and of auxiliary verbs. Whence," he continues, "may be inferred, (however we may flatter ourselves with the idea of our own superiority), that the human intellect was much more acute and subtile in ancient, than it now is in modern times."[1] How very unlike is this last reflection to the usual strain of Bacon's writings! It seems, indeed, much more congenial to the philosophy of Mr Harris and of Lord Monboddo; and it has accordingly been sanctioned with the approbation of both these learned authors. If my memory does not deceive me, it is the only passage in Bacon's works, which Lord Monboddo has anywhere condescended to quote.

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[1] Notwithstanding the extravagance of Spinoza's own philosophical creed, he is one of the very few among Bacon's successors, who seem to have been fully aware of the justness, importance, and originality of the method pointed out in the *Novum Organon* for the study of the Mind. "Ad hæc intelligenda, non est opus *naturam mentis* cognoscere, sed sufficit, mentis sive *perceptionum* historiolam concinnare modo illo quo VERULAMIUS docet."—SPIN. *Epist.* 42.

In order to comprehend the whole merit of this remark, it is necessary to know that, according to the Cartesian phraseology, which is here adopted by Spinoza, the word *perception* is a general term, equally applicable to all the intellectual operations. The words of Descartes himself are these: "Omnes modi cogitandi, quos in nobis experimur, ad duos generales referri possunt: quorum unus est, *perceptio*, sive operatio intellectus; alius vero, *volitio*, sive operatio voluntatis. *Nam sentiri, imaginari, et pure intelligere, sunt tantum diversi modi percipiendi;* ut et cupere, aversari, affirmare, negare, dubitare, sunt diversi modi volendi."—*Princip. Phil.* Pars I. § 32.

[2] *De Aug. Scient.* Lib. vi. cap. i.

[3] *Ibid.*

These observations afford me a convenient opportunity for remarking the progress and diffusion of *the philosophical spirit*, since the beginning of the seventeenth century. In the short passage just cited from Bacon, there are involved no less than two capital errors, which are now almost universally ranked, by men of education, among the grossest prejudices of the multitude. The one, that the declensions and conjugations of the ancient languages, and the modern substitution in their place of prepositions and auxiliary verbs, are, both of them, the deliberate and systematical contrivances of speculative grammarians; the other (still less analogous to Bacon's general style of reasoning), that the faculties of man have declined, as the world has grown older. Both of these errors may be now said to have disappeared entirely. The latter, more particularly, must, to the rising generation, seem so absurd, that it almost requires an apology to have mentioned it. That the capacities of the human mind have been in all ages the same; and that the diversity of phenomena exhibited by our species, is the result merely of the different circumstances in which men are placed, has been long received as an incontrovertible logical maxim, or rather, such is the influence of early instruction, that we are apt to regard it as one of the most obvious suggestions of common sense. And yet, till about the time of Montesquieu, it was by no means so generally recognised by the learned, as to have a sensible influence on the fashionable tone of thinking over Europe. The application of this fundamental and leading idea to the natural or *theoretical history* of society in all its various aspects;—to the history of languages, of the arts, of the sciences, of laws, of government, of manners, and of religion,—is the peculiar glory of the latter half of the eighteenth century, and forms a characteristical feature in its philosophy, which even the imagination of Bacon was unable to foresee.

It would be endless to particularize the original suggestions thrown out by Bacon on topics connected with the science of Mind. The few passages of this sort already quoted, are produced merely as a specimen of the rest. They are by no means selected as the most important in his writings; but as they happened to be those which had left the strongest impression on my memory, I thought them as likely as any other, to invite the curiosity of my readers to a careful examination of the rich mine from which they are extracted.

The Ethical disquisitions of Bacon are almost entirely of a practical nature. Of the two theoretical questions so much agitated, in both parts of this island, during the eighteenth century, concerning the *principle* and the *object* of moral approbation, he has said nothing; but he has opened some new and interesting views with respect to the influence of *custom* and the formation of *habits*;—a most important article of moral philosophy, on which he has enlarged more ably and more usefully than any writer since Aristotle.[2] Under the same head of *Ethics* may be mentioned the small volume to which he has given the title of *Essays;* the best known and the most popular of all his works. It is also one of those where the superiority of his genius appears to the greatest advantage; the novelty and depth of his reflections often receiving a strong relief from the triteness of his subject. It may be read from beginning to end in a few hours,—and yet, after the twentieth perusal, one seldom fails to remark in it something overlooked before. This, indeed, is a characteristic of all Bacon's writings, and is only to be accounted for by the inexhaustible aliment they furnish to our own thoughts, and the sympathetic activity they impart to our torpid faculties.

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[1] *De Aug. Scient.* Lib. vi. cap. i.

[2] *De Aug. Scient.* Lib. vii. cap. iii.

The suggestions of Bacon for the improvement of Political Philosophy, exhibit as strong a contrast to the narrow systems of contemporary statesmen, as the Inductive Logic to that of the Schools. How profound and comprehensive are the views opened in the following passages, when compared with the scope of the celebrated treatise *De Jure Belli et Pacis;* a work which was first published about a year before Bacon's death, and which continued, for a hundred and fifty years afterwards, to be regarded in all the Protestant universities of Europe as an inexhaustible treasure of moral and jurisprudential wisdom!

"The ultimate object which legislators ought to have in view, and to which all their enactments and sanctions ought to be subservient, is, *that the citizens may live happily.* For this purpose, it is necessary that they should receive a religious and pious education; that they should be trained to good morals; that they should be secured from foreign enemies by proper military arrangements; that they should be guarded by an effectual police against seditions and private injuries; that they should be loyal to government, and obedient to magistrates; and, finally, that they should abound in wealth, and in other national resources."[1]—"The science of such matters certainly belongs more particularly to the province of men who, by habits of public business, have been led to take a comprehensive survey of the social order; of the interests of the community at large; of the rules of natural equity; of the manners of nations; of the different forms of government; and who are thus prepared to reason concerning the wisdom of laws, both from considerations of justice and of policy. The great desideratum, accordingly, is, by investigating the principles of *natural justice*, and those of *political expediency*, to exhibit a theoretical model of legislation, which, while it serves as a standard for estimating the comparative excellence of municipal codes, may suggest hints for their correction and improvement, to such as have at heart the welfare of mankind."[2]

How precise the notion was that Bacon had formed of a philosophical system of jurisprudence (with which as a standard the municipal laws of different nations might be compared), appears from a remarkable expression, in which he mentions it as the proper business of those who might attempt to carry his plan into execution, to investigate those "LEGES LEGUM, ex quibus informatio peti possit, quid in singulis legibus bene aut perperam positum aut constitutum sit."[3] I do not know if, in Bacon's

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[1] *Exemplum Tractatus de Fontibus Juris*, Aphor. 5. This enumeration of the different objects of law approaches very nearly to Mr Smith's ideas on the same subject, as expressed by himself in the concluding sentence of his *Theory of Moral Sentiments.* "In another Discourse, I shall endeavour to give an account of the general principles of law and government, and of the different revolutions they have undergone in the different ages and periods of society; not only in what concerns justice, but in what concerns police, revenue, and arms, and whatever else is the object of law."

[2] *De Aug. Scient.* Lib. viii. cap. iii.

[3] *De Fontibus Juris*, Aphor. 6.

From the preface to a small tract of Bacon's entitled, *The Elements of the Common Laws of England*, written while he was Solicitor-General to Queen Elizabeth, we learn, that the phrase *legum leges* had been previously used by some "great Civilian." To what *Civilian* Bacon here alludes, I know not; but, whoever he was, I doubt much if he annexed to it the comprehensive and philosophical meaning so precisely explained in the above definition. Bacon himself, when he wrote his Tract on the Common Laws, does not seem to have yet risen to this vantage-ground of Universal Jurisprudence. His great object (he tells us) was "to collect the rules and grounds dispersed throughout the body of the same laws, in order to see more profoundly into the reason of such judgments and ruled cases, and thereby to make more use of them for the decision of other cases more doubtful; so that the uncertainty of law, which is the principal and most just challenge that is made to the laws of our nation at this time, will, by this new strength laid to the foundation, be somewhat the more settled and corrected." In this passage, no reference whatever is made to the *Universal Justice* spoken of in the aphorisms *De Fontibus Juris;* but merely to the leading and governing rules which give to a municipal system whatever it possesses of prophetic anticipations of the future progress of Physics, there be any thing more characteristical, both of the grandeur and of the justness of his conceptions, than this short definition; more particularly, when we consider how widely Grotius, in a work professedly devoted to this very inquiry, was soon after to wander from the right path, in consequence of his vague and wavering idea of the aim of his researches.

The sagacity, however, displayed in these, and various other passages of a similar import, can by no means be duly appreciated, without attending, at the same time, to the cautious and temperate maxims so frequently inculcated by the author, on the subject of political innovation. "A stubborn retention of customs is a turbulent thing, not less than the introduction of new."—"Time is the greatest innovator; shall we then not imitate time, which innovates so silently as to mock the sense?" Nearly connected with these aphorisms, are the profound reflections in the first book *De Augmentis Scientiarum*, on the necessity of accommodating every new institution to the character and circumstances of the people for whom it is intended; and on the peculiar danger which literary men run of overlooking this consideration, from the familiar acquaintance they acquire, in the course of their early studies, with the ideas and sentiments of the ancient classics.

The remark of Bacon on the systematical policy of Henry VII. was manifestly suggested by the same train of thinking. "His laws (whoso marks them well) were deep and not vulgar; not made on the spur of a particular occasion for the present, but out of providence for the future; to make the estate of his people still more and more happy, after the manner of the legislators in ancient and heroic times." How far this noble eulogy was merited, either by the legislators of antiquity, or by the modern Prince on whom Bacon has bestowed it, is a question of little moment. I quote it merely on account of the important philosophical distinction which it indirectly marks, between "deep and vulgar laws;" the former invariably aiming to accomplish their end, not by giving any sudden shock to the feelings and interests of the existing generation, but by allowing to natural causes time and opportunity to operate; and by removing those artificial obstacles which check the progressive tendencies of society. It is probable, that, on this occasion, Bacon had an eye more particularly to the memorable *statute of alienation;* to the effects of which (whatever were the motives of its author) the above description certainly applies in an eminent degree.

After all, however, it must be acknowledged, that it is rather in his general views and maxims, than in the details of his political theories, that Bacon's sagacity appears to advantage. His notions with respect to commercial policy seem to have been more peculiarly erroneous; originating in an overweening opinion of the efficacy of law, in matters where natural causes ought to be allowed a free operation. It is observed by Mr Hume, that the statutes of Henry VII. relating to the police of his kingdom, are generally contrived with more judgment than his commercial regulations. The same writer adds, that "the more simple ideas of order and equity are sufficient to guide a legislator in every thing that regards the internal administration of justice; but that the principles of commerce are much more complicated, and require long experience and deep reflection to be well understood in any state. The real consequence is *there* often contrary to first appearances. No wonder, that, during the reign of Henry VII., these matters were frequently mistaken; and it may safely be affirmed, that, even in the age of Lord Bacon, very imperfect and erroneous ideas were formed on that subject."

The instances mentioned by Hume in confirmation of these general remarks, are peculiarly gratifying to those who have a pleasure in tracing the slow but certain progress of reason and liberality. "During the reign," says he, "of Henry VII. it was prohibited to ex-

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analogy and consistency. To these rules Bacon gives the title of *leges legum;* but the meaning of the phrase, on this occasion, differs from that in which he afterwards employed it, not less widely than the rules of Latin or of Greek syntax differ from the principles of universal grammar.

port horses, as if that exportation did not encourage the breed, and make them more plentiful in the kingdom. Prices were also affixed to woollen cloths, to caps and hats, and the wages of labourers were regulated by law. It is evident, *that these matters ought always to be left free, and be entrusted to the common course of business and commerce.*"—"For a like reason," the historian continues, the "law enacted against inclosures, and for the keeping up of farm-houses, scarcely deserves the praises bestowed on it by Lord Bacon. If husbandmen understand agriculture, and have a ready vent for their commodities, we need not dread a diminution of the people employed in the country. During a century and a half after this period, there was a frequent renewal of laws and edicts against depopulation; whence we may infer, that none of them were ever executed. *The natural course of improvement at last provided a remedy.*"

These acute and decisive strictures on the impolicy of some laws highly applauded by Bacon, while they strongly illustrate the narrow and mistaken views in political economy entertained by the wisest statesmen and philosophers two centuries ago, afford, at the same time, a proof of the general diffusion which has since taken place among the people of Great Britain, of juster and more enlightened opinions on this important branch of legislation. Wherever such doctrines find their way into the page of history, it may be safely inferred, that the public mind is not indisposed to give them a welcome reception.

The ideas of Bacon concerning the education of youth, were such as might be expected from a philosophical statesman. On the conduct of education in general, with a view to the developement and improvement of the intellectual character, he has suggested various useful hints in different parts of his works; but what I wish chiefly to remark at present is, the paramount importance which he has attached to the education of the people,—comparing, as he has repeatedly done, the effects of early culture on the understanding and the heart, to the abundant harvest which rewards the diligent husbandman for the toils of the spring. To this analogy he seems to have been particularly anxious to attract the attention of his readers, by bestowing on education the title of *the Georgics of the Mind;* identifying, by a happy and impressive metaphor, the two proudest functions entrusted to the legislator,—the encouragement of agricultural industry, and the care of national instruction. In both instances, the legislator exerts a power which is literally *productive* or *creative;* compelling, in the one case, the unprofitable desert to pour forth its latent riches; and in the other, vivifying the dormant seeds of genius and virtue, and redeeming from the neglected wastes of human intellect, a new and unexpected accession to the common inheritance of mankind.

When from such speculations as these we descend to the treatise *De Jure Belli et Pacis*, the contrast is mortifying indeed. And yet, so much better suited were the talents and accomplishments of Grotius to the taste, not only of his contemporaries, but of their remote descendants, that, while the merits of Bacon failed, for a century and a half, to command the general admiration of Europe,[1] Grotius continued, even in our British universities, the acknowledged Oracle of Jurisprudence and of Ethics, till long after the death of Montesquieu. Nor was Bacon himself unapprised of the slow growth of his posthumous fame. No writer seems ever to have felt more deeply, that he properly belonged to a later and more enlightened age;—a sentiment which he has pathetically expressed in that clause of his testament where he "bequeaths his name to posterity, after some generations shall be past."[2]

Unbounded, however, as the reputation of Grotius was on the Continent, even before his own death, it was not till many years after the publication of the treatise *De Jure Belli et Pacis*, that the science of Natural Jurisprudence became, in this island, an object of much attention, even to the learned. In order, therefore, to give to the sequel of this section some degree of continuity, I shall reserve my observations on Grotius and his successors, till I shall have finished all that I think it necessary to mention further, with respect to the literature of our own country, prior to the appearance of Mr Locke's Essay.

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[1] "La célébrité en France des écrits du Chancelier Bacon n'a guère pour date que celle de l'Encyclopédie."—(*Histoire des Mathématiques par Montucla*, Preface, p. ix.) It is an extraordinary circumstance, that Bayle, who has so often wasted his erudition and acuteness on the most insignificant characters, and to whom Le Clerc has very justly ascribed the merit of *une exactitude étonnante dans des choses de néant*, should have devoted to Bacon only twelve lines of his Dictionary.

[2] See Note F.

The rapid advancement of intellectual cultivation in England, between the years 1588 and 1640 (a period of almost uninterrupted peace), has been remarked by Mr Fox. "The general improvement," he observes, "in all arts of civil life, and, above all, the astonishing progress of literature, are the most striking among the general features of that period; and are in themselves causes sufficient to produce effects of the utmost importance. A country whose language was enriched by the works of Hooker, Raleigh, and Bacon, could not but experience a sensible change in its manners, and in its style of thinking; and even to speak the same language in which Spencer and Shakspeare had written, seemed a sufficient plea to rescue the Commons of England from the appellation of *Brutes*, with which Henry the Eighth had addressed them."—The remark is equally just and refined. It is by the mediation of an improving language, that the progress of the mind is chiefly continued from one generation to another; and that the acquirements of the enlightened few are insensibly imparted to the many. Whatever tends to diminish the ambiguities of speech, or to fix, with more logical precision, the import of general terms;—above all, whatever tends to embody, in popular forms of expression, the ideas and feelings of the wise and good, augments the natural powers of the human understanding, and enables the succeeding race to start from a higher ground than was occupied by their fathers. The remark applies with peculiar force to the study of the Mind itself; a study, where the chief source of error is the imperfection of words; and where every improvement on this great instrument of thought may be justly regarded in the light of a discovery.[1]

In the foregoing list of illustrious names, Mr Fox has, with much propriety, connected those of Bacon and Raleigh; two men, who, notwithstanding the diversity of their professional pursuits, and the strong contrast of their characters, exhibit, nevertheless, in their capacity of authors, some striking features of resemblance. Both of them owed to the force of their own minds, their emancipation from the fetters of the schools; both were eminently distinguished above their contemporaries, by the originality and enlargement of their philosophical views; and both divide, with the venerable Hooker, the glory of exemplifying, to their yet unpolished countrymen, the richness, variety, and grace, which might be lent to the English idiom, by the hand of a master.[2]

It is not improbable that Mr Fox might have included the name of Hobbes in the same enumeration, had he not been prevented by an aversion to his slavish principles of government, and by his own disrelish for metaphysical theories. As a writer, Hobbes unquestionably ranks high among the older English classics, and is so peculiarly distinguished by the simplicity and ease of his manner, that one would naturally have expected from Mr Fox's characteristical taste, that he would have relished *his* style still more than that of Bacon[1] or of Raleigh. It is with the *philosophical* merits, however, of Hobbes, that we are alone concerned at present; and, in this point of view, what a space is filled in the subsequent history of our domestic literature, by his own works, and by those of his innumerable opponents! Little else, indeed, but the systems which he published, and the controversies which they provoked, occurs, during the interval between Bacon and Locke, to mark the progress of English Philosophy, either in the study of the Mind, or in the kindred researches of Ethical and Political Science.

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[1] It is not so foreign as may at first be supposed to the object of this Discourse, to take notice here of the extraordinary demand for books on *Agriculture* under the government of James I. The fact is thus very strongly stated by Dr Johnson, in his introduction to the Harleian Miscellany. "It deserves to be remarked, because it is not generally known, that the treatises on husbandry and agriculture, which were published during the reign of King James, are so numerous, that it can scarcely be imagined by whom they were written, or to whom they were sold." Nothing can illustrate more strongly the effects of a pacific system of policy, in encouraging a general taste for reading, as well as an active spirit of national improvement. At all times, and in every country, the extensive sale of *books on agriculture*, may be regarded as one of the most pleasing symptoms of mental cultivation in the great body of a people.

[2] To prevent being misunderstood, it is necessary for me to add, that I do not speak of the *general style* of these old authors; but only of detached passages, which may be selected from all of them, as earnests or first fruits of a new and brighter era in English literature. It may be safely affirmed, that in *their* works, and in the prose compositions of Milton, are to be found some of the finest sentences of which our language has yet to boast. To propose them *now* as models for imitation would be quite absurd. Dr Lowth certainly went much too far when he said, "That in *correctness*, *propriety*, and *purity* of English style, Hooker hath hardly been surpassed, or even equalled, by any of his successors."—*Preface to* Lowth's *English Grammar*.

Of the few and comparatively trifling exceptions to this remark, furnished by the metaphysical tracts of Glanville, of Henry More, and of John Smith, I must delay taking notice, till some account shall be given of the Cartesian Philosophy; to which their most interesting discussions have a constant reference, either in the way of comment or refutation.

HOBBES.[2]

"The philosopher of Malmesbury," says Dr Warburton, "was the terror of the last age, as Tindall and Collins are of this. The press sweat with controversy; and every young churchman militant, would try his arms in thundering on Hobbes's steel cap."[3] Nor was the opposition to Hobbes confined to the clerical order, or to the controversialists of his own times. The most eminent moralists and politicians of the eighteenth century may be ranked in the number of his antagonists; and even at the present moment, scarcely does there appear a new publication on Ethics or Jurisprudence, where a refutation of Hobbism is not to be found.

The period when Hobbes began his literary career, as well as the principal incidents of his life, were, in a singular degree, favourable to a mind like his; impatient of the yoke of authority, and ambitious to attract attention, if not by solid and useful discoveries, at least by an ingenious defence of paradoxical tenets. After a residence of five years at Oxford, and a very extensive tour through France and Italy, he had the good fortune, upon his return to England, to be admitted into the intimacy and confidence of Lord Bacon; a circumstance which, we may presume, contributed not a little to encourage that bold spirit of inquiry, and that aversion to scholastic learning, which characterise his writings. Happy, if he had, at the same time, imbibed some portion of that love of truth and zeal for the advancement of knowledge, which seem to have been Bacon's ruling passions! But such was the obstinacy of his temper, and his overweening self-conceit, that, instead of co-operating with Bacon in the execution of his magnificent design, he resolved to rear, on a foundation exclusively his own, a complete structure both of Moral and Physical Science; disdaining to avail himself even of the materials collected by his predecessors, and treating the *experimentarian* philosophers as objects only of contempt and ridicule![4]

In the *political* writings of Hobbes, we may perceive the influence also of other motives. From his earliest years, he seems to have been decidedly hostile to all the forms of popular government; and it is said to have been with the design of impressing his countrymen with a just sense of the disorders incident to democratical establishments, that he published, in 1618, an English translation of Thucydides. In these opinions he was more and more confirmed by the events he afterwards witnessed in England; the fatal consequences of which he early foresaw with so much alarm, that, in 1640, he withdrew from the approaching storm, to enjoy the society of his philosophical friends at Paris. It was there he wrote his book *De Cive*, a few copies of which were printed, and privately circulated in 1642. The same work was afterwards given to the public, with material corrections and improvements, in 1647, when the author's attachment to the royal cause being strengthened by his personal connection with the exiled king, he thought it incumbent on him to stand forth avowedly as an advocate for those principles which he had long professed. The great object of this performance was to strengthen the hands of sovereigns against the rising spirit of democracy, by arming them with the weapons of a new philosopby.

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[1] According to Dr Burnet (no contemptible judge of style), Bacon was "the first that *writ* our language correctly." The same learned prelate pronounces Bacon to be "*still* our best author;" and *this*, at a time when the works of Sprat, and many of the prose compositions of Cowley and of Dryden, were already in the hands of the public. It is difficult to conceive on what grounds Burnet proceeded, in hazarding so extraordinary an opinion.—See the preface to BURNET's Translation of MORE's *Utopia*.

It is still more difficult, on the other hand, to account for the following very bold decision of Mr Hume. I transcribe it from an essay first published in 1742; but the same passage is to be found in the last edition of his works, corrected by himself. "The first polite prose we have, was *writ* by a man (Dr Swift) who is still alive. As to Sprat, Locke, and even Temple, they knew too little of the rules of art to be esteemed elegant writers. The prose of Bacon, Harrington, and Milton, is altogether stiff and pedantic, though their sense be excellent."

How insignificant are the petty grammatical improvements proposed by Swift, when compared with the inexhaustible riches imparted to the English tongue by the writers of the seventeenth century; and how inferior, in all the higher qualities and graces of style, are his prose compositions, to those of his immediate predecessors, Dryden, Pope, and Addison!

[2] Born 1588, died 1679.

[3] *Divine Legation*, Pref. to Vol. II. p. 9.

[4] See Note G.

The fundamental doctrines inculcated in the political works of Hobbes are contained in the following propositions. I recapitulate them here, not on their own account, but to prepare the way for some remarks which I mean afterwards to offer on the coincidence between the principles of Hobbes and those of Locke. In their practical conclusions, indeed, with respect to the rights and duties of citizens, the two writers differ widely; but it is curious to observe how very nearly they set out from the same hypothetical assumptions.

All men are by nature equal; and, prior to government, they had all an equal right to enjoy the good things of this world. Man, too, is (according to Hobbes) by nature a solitary and purely selfish animal; the social union being entirely an interested league, suggested by prudential views of personal advantage. The necessary consequence is, that a state of nature must be a state of perpetual warfare, in which no individual has any other means of safety than his own strength or ingenuity; and in which there is no room for regular industry, because no secure enjoyment of its fruits. In confirmation of this view of the origin of society, Hobbes appeals to facts falling daily within the circle of our own experience. "Does not a man (he asks), when taking a journey, arm himself, and seek to go well accompanied? When going to sleep, does he not lock his doors? Nay, even in his own house, does he not lock his chests? Does he not *there* as much accuse mankind by his actions, as I do by my words?"[1] An additional argument to the same purpose may, according to some later Hobbists, be derived from the instinctive aversion of infants for strangers; and from the apprehension which, it is alleged, every person feels, when he hears the tread of an unknown foot in the dark.

For the sake of peace and security, it is necessary that each individual should surrender a part of his natural right, and be contented with such a share of liberty as he is willing to allow to others; or, to use Hobbes's own language, "every man must divest himself of the right he has to all things by nature; the right of all men to all things being in effect no better than if no man had a right to any thing."[2] In consequence of this transference of natural rights to an individual, or to a body of individuals, the multitude become one person, under the name of a State or Republic, by which person the common will and power are exercised for the common defence. The ruling power cannot be withdrawn from those to whom it has been committed; nor can they be punished for misgovernment. The interpretation of the laws is to be sought, not from the comments of philosophers, but from the authority of the ruler; otherwise society would every moment be in danger of resolving itself into the discordant elements of which it was at first composed. The will of the magistrate, therefore, is to be regarded as the ultimate standard of right and wrong, and his voice to be listened to by every citizen as the voice of conscience.

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[1] *Of Man*, Part I. chap. xiii.
[2] *De Corpore Politico*, Part I chap. i. § 10.

Not many years afterwards,[1] Hobbes pushed the argument for the absolute power of princes still further, in a work to which he gave the name of *Leviathan.* Under this appellation he means the *body politic ;* insinuating that man is an untameable beast of prey, and that government is the strong chain by which he is kept from mischief. The fundamental principles here maintained are the same as in the book *De Cive;* but as it inveighs more particularly against *ecclesiastical* tyranny, with the view of subjecting the consciences of men to the civil authority, it lost the author the favour of some powerful protectors he had hitherto enjoyed among the English divines who attended Charles II. in France; and he even found it convenient to quit that kingdom, and to return to England, where Cromwell (to whose government his political tenets were *now* as favourable as they were meant to be to the royal claims) suffered him to remain unmolested. The same circumstances operated to his disadvantage after the Restoration, and obliged the King, who always retained for him a very strong attachment, to confer his marks of favour on him with the utmost reserve and circumspection.[2]

The details which I have entered into, with respect to the history of Hobbes's political writings, will be found, by those who may peruse them, to throw much light on the author's reasonings. Indeed, it is only by thus considering them in their connection with the circumstances of the times, and the fortunes of the writer, that a just notion can be formed of their spirit and tendency.

The ethical principles of Hobbes are so completely interwoven with his political system, that all which has been said of the one may be applied to the other. It is very remarkable, that Descartes should have thought so highly of the former, as to pronounce Hobbes to be "a much greater master of morality than of metaphysics;" a judgment which is of itself sufficient to mark the very low state of ethical science in France about the middle of the seventeenth century. Mr Addison, on the other hand, gives a decided preference (among all the books written by Hobbes) to his *Treatise on Human Nature ;* and to *his* opinion on this point I most implicitly subscribe; including, however, in the same commendation, some of his other philosophical essays on similiar topics. They are the only part of his works which it is possible now to read with any interest; and they everywhere evince in their author, even when he thinks most unsoundly himself, that power of setting his reader a-thinking, which is one of the most unequivocal marks of original genius. They have plainly been studied with the utmost care both by Locke and Hume. To the former they have suggested some of his most important observations on the Association of Ideas, as well as much of the sophistry displayed in the first book of his Essay, on the Origin of our Knowledge, and on the factitious nature of our moral principles; to the latter (among a variety of hints of less consequence), his theory concerning the nature of those established connections among physical events, which it is the business of the natural philosopher to ascertain,[3] and the substance of his argument against the scholastic doctrine of general conceptions. It is from the works of Hobbes, too, that our later Necessitarians have borrowed the most formidable of those weapons with which they have combated the doctrine of moral liberty; and from the same source has been derived the leading idea which runs through the philological materialism of Mr Horne Tooke. It is probable, indeed, that this last author borrowed it, at second-hand, from a hint in Locke's Essay; but it is repeatedly stated by Hobbes, in the most explicit and confident terms. Of this idea (than which, in point of fact, nothing can be imagined more puerile and unsound), Mr Tooke's etymologies, when he applies them to the solution of metaphysical questions, are little more than an ingenious expansion, adapted and levelled to the comprehension of the multitude.

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[1] In 1651.

[2] See Note H.

[3] The same doctrine, concerning the proper object of natural philosophy (commonly ascribed to Mr Hume, both by his followers and by his opponents), is to be found in various writers contemporary with Hobbes. It is stated, with uncommon precision and clearness, in a book entitled *Scepsis Scientifica*, or Confessed Ignorance the way to Science, by Joseph Glanvill, (printed in 1665). The whole work is strongly marked with the features of an acute, an original, and, in matters of science, a somewhat sceptical genius; and, when compared with the treatise on witchcraft, by the same author, adds another proof to those already mentioned, of the possible union of the highest intellectual gifts with the most degrading intellectual weaknesses.

With respect to the *Scepsis Scientifica*, it deserves to be noticed, that the doctrine maintained in it concerning *physical* causes and effects does not occur in the form of a detached observation, of the value of which the author might not have been fully aware, but is the very basis of the general argument running through all his discussions.

The speculations of Hobbes, however, concerning the theory of the understanding, do not seem to have been nearly so much attended to during his own life, as some of his other doctrines, which, having a more immediate reference to human affairs, were better adapted to the unsettled and revolutionary spirit of the times. It is by these doctrines, chiefly, that his name has since become so memorable in the annals of modern literature; and although they now derive their whole interest from the extraordinary combination they exhibit of acuteness and subtlety with a dead-palsy in the powers of taste and of moral sensibility, yet they will be found, on an attentive examination, to have had a far more extensive influence on the subsequent history, both of political and of ethical science, than any other publication of the same period.

ANTAGONISTS OF HOBBES.

Cudworth[1] was one of the first who successfully combated this new philosophy. As Hobbes, in the frenzy of his political zeal, had been led to sacrifice wantonly all the principles of religion and morality to the establishment of his conclusions, his works not only gave offence to the friends of liberty, but excited a general alarm among all sound moralists. His doctrine, in particular, that there is no *natural* distinction between Right and Wrong, and that these are dependent on the arbitrary will of the civil magistrate, was so obviously subversive of all the commonly received ideas concerning the moral constitution of human nature, that it became indispensably necessary, either to expose the sophistry of the attempt, or to admit, with Hobbes, that man is a beast of prey, incapable of being governed by any motives but fear, and the desire of self-preservation.

Between some of these tenets of the courtly Hobbists, and those inculcated by the Cromwellian Antinomians, there was a very extraordinary and unfortunate coincidence; the latter insisting, that, in expectation of Christ's second coming, "the obligations of morality and natural law were suspended; and that the elect, guided by an internal principle, more perfect and divine, were superior to the *beggarly elements* of justice and humanity."[2] It was the object of Cudworth to vindicate, against the assaults of both parties, the immutability of moral distinctions.

In the prosecution of his very able argument on this subject, Cudworth displays a rich store of enlightened and choice erudition, penetrated throughout with a peculiar vein of sobered and subdued Platonism, from whence some German systems, which have attracted no small notice in our own times, will be found, when stripped of their deep neological disguise, to have borrowed their most valuable materials.[3]

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[1] Born 1617, died 1688.

[2] Hume.—For a more particular account of the English Antinomians, See Mosheim, Vol. IV. p. 534, *et seq.*

[3] The mind, according to Cudworth, perceives, by occasion of outward objects, as much more than is represented to it by sense, as a learned man does in the best written book, than an illiterate person or brute. "To the eyes of both, the same characters will appear; but the learned man, in those characters, will see heaven, earth, sun, and stars; read profound theorems of philosophy or geometry; learn a great deal of new knowledge from them, and admire the wisdom of the composer; while, to the other, nothing appears but black strokes drawn on white paper. The reason of which is, that the mind of the one is furnished with certain previous inward anticipations, ideas, and instruction, that the other wants."—"In the room of this book of *human* composition, let us now substitute the book of Nature, written all over with the characters and impressions of *divine* wisdom and goodness, but legible only to an intellectual eye. To the sense both of man and brute, there appears nothing else in it, but, as in the other, so many inky scrawls; that is, nothing but figures and colours. But the mind, which hath a participation of the divine wisdom that made it, upon occasion of those sensible delineations, exerting its own inward activity, will have not only a wonderful scene, and large prospects of

Another coincidence between the Hobbists and the Antinomians, may be remarked in their common zeal for the scheme of *necessity;* which both of them stated in such a way as to be equally inconsistent with the moral agency of man, and with the moral attributes of God.[1] The strongest of all presumptions against this scheme is afforded by the other tenets with which it is almost universally combined; and accordingly, it was very shrewdly observed by Cudworth, that the *licentious system* which flourished in his time (under which title, I presume, he comprehended the immoral tenets of the fanatics as well as of the Hobbists), "grew up from the doctrine of the fatal necessity of all actions and events, as from its proper root." The unsettled, and, at the same time, disputatious period during which Cudworth lived, afforded him peculiarly favourable opportunities of judging from experience, of the practical tendency of this metaphysical dogma; and the result of his observations deserves the serious attention of those who may be disposed to regard it in the light of a fair and harmless theme for the display of controversial subtility. To argue, in this manner, against a speculative principle from its palpable effects, is not always so illogical as some authors have supposed. "You repeat to me incessantly," says Rousseau to one of his correspondents, "that truth can never be injurious to the world. I myself believe so as firmly as you do; and it is for this very reason I am satisfied that your proposition is false."[2]

But the principal importance of Cudworth, as an ethical writer, arises from the influence of his argument concerning the immutability of right and wrong on the various theories of morals which appeared in the course of the eighteenth century. To this argument may, more particularly, be traced the origin of the celebrated question, Whether the principle of moral approbation is to be ultimately resolved into Reason, or into Sentiment?—a question which has furnished the chief ground of difference between the Systems of Cudworth and of Clarke, on the one hand; and those of Shaftesbury, Hutcheson, Hume, and Smith, on the other. The remarks which I have to offer on this controversy must evidently be delayed, till the writings of these more modern authors shall fall under review.

The *Intellectual System* of Cudworth embraces a field much wider than his treatise of *Immutable Morality.* The latter is particularly directed against the ethical doctrines of Hobbes, and of the Antinomians; but the former aspires to tear up by the roots all the principles, both physical and metaphysical, of the Epicurean philosophy. It is a work, certainly, which reflects much honour on the talents of the author, and still more on the boundless extent of his learning; but it is so ill suited to the taste of the present age, that, since the time of Mr Harris and Dr Price, I scarcely recollect the slightest reference to it in the writings of our British metaphysicians. Of its faults (beside the general disposition of the author to discuss questions placed altogether beyond the reach of our faculties), the most prominent is the wild hypothesis of a *plastic nature;* or, in other words, "of a vital and spiritual, but unintelligent and necessary agent, created by the Deity for the execu-

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other thoughts laid open before it, and variety of knowledge, logical, mathematical, and moral, displayed; but also clearly read the divine wisdom and goodness in every page of this great volume, as it were written in large and legible characters."

I do not pretend to be an adept in the philosophy of Kant; but I certainly think I pay it a very high compliment, when I suppose, that, in the *Critic of Pure Reason*, the leading idea is somewhat analogous to what is so much better expressed in the foregoing passage. To Kant it was probably suggested by the following very acute and decisive remark of Leibnitz on Locke's Essay: "Nempe, nihil est in intellectu, quod non fuerit in sensu, *nisi ipse intellectus.*"

In justice to Aristotle, it may be here observed, that, although the general strain of his language is strictly conformable to the scholastic maxim just quoted, he does not seem to have altogether overlooked the important exception to it pointed out by Leibnitz. Indeed, this exception or limitation is very nearly a translation of Aristotle's words. Καὶ αὐτὸς δὲ (νοῦς) νοητός ἐστιν, ὥσπερ τὰ νοητά· ἐπὶ μὲν γὰρ τῶν ἄνευ ὕλης, τὸ αὐτο ἐστι νοοῦν, καὶ τὸ νοούμενον. "And the mind itself is an object of knowledge, as well as other things which are intelligible. For, in immaterial beings, that which understands is the same with that which is understood."—(*De Anima*, Lib. iii. cap. iv.) I quote this very curious, and, I suspect, very little known sentence, in order to vindicate Aristotle against the misrepresentations of some of his present idolators, who, in their anxiety to secure to him all the credit of Locke's doctrine concerning the origin of our Ideas, have overlooked the occasional traces which occur in his works, of that higher and sounder philosophy in which he had been educated.

[1] "The doctrines of fate or destiny were deemed by the Independents essential to all religion. In these rigid opinions, *the whole sectaries*, amidst all their other differences, unanimously concurred."—HUME's *History*, chap. lvii.

[2] "Vous répetez sans cesse que la vérité ne peut jamais faire de mal aux hommes; je le crois, et c'est pour moi la preuve que ce que vous dites n'est pas la vérité."

tion of his purposes." Notwithstanding, however, these, and many other abatements of its merits, *the Intellectual System* will for ever remain a precious mine of information to those whose curiosity may lead them to study the spirit of the ancient theories; and to *it* we may justly apply what Leibnitz has somewhere said, with far less reason, of the works of the schoolmen, "Scholasticos agnosco abundare ineptiis; *sed aurum est in illo cœno.*"[1]

Before dismissing the doctrines of Hobbes, it may be worth while to remark, that all his leading principles are traced by Cudworth to the remains of the ancient sceptics, by some of whom, as well as by Hobbes, they seem to have been adopted from a wish to flatter the uncontrolled passions of sovereigns. Not that I am disposed to call in question the originality of Hobbes; for it appears, from the testimony of all his friends, that he had much less pleasure in reading than in thinking. "If I had read," he was accustomed to say, "as much as some others, I should have been as ignorant as they are." But similar political circumstances invariably reproduce similar philosophical theories; and it is one of the numerous disadvantages attending an inventive mind, not properly furnished with acquired information, to be continually liable to a waste of its powers on subjects previously exhausted.

The sudden tide of licentiousness, both in principles and in practice, which burst into this island at the moment of the Restoration, conspired with the paradoxes of Hobbes, and with the no less dangerous errors recently propagated among the people by their religious instructors, to turn the thoughts of sober and speculative men towards ethical disquisitions. The established clergy assumed a higher tone than before in their sermons; sometimes employing them in combating that Epicurean and Machiavelian philosophy which was then fashionable at court, and which may be always suspected to form the secret creed of the enemies of civil and religious liberty;—on other occasions, to overwhelm, with the united force of argument and learning, the extravagances by which the ignorant enthusiasts of the preceding period had exposed Christianity itself to the scoffs of their libertine opponents. Among the divines who appeared at this era, it is impossible to pass over in silence the name of Barrow, whose theological works (adorned throughout by classical erudition, and by a vigorous, though unpolished eloquence), exhibit, in every page, marks of the same inventive genius which, in mathematics, has secured to him a rank second alone to that of Newton. As a writer, he is equally distinguished by the redundancy of his matter, and by the pregnant brevity of his expression; but what more peculiarly characterises his manner, is a certain air of powerful and of conscious facility in the execution of whatever he undertakes. Whether the subject be mathematical, metaphysical, or theological, he seems always to bring to it a mind which feels itself superior to the occasion; and which, in contending with the greatest difficulties, "puts forth but half its strength." He has somewhere spoken of his *Lectiones Mathematicæ* (which it may, in passing, be remarked, display *metaphysical* talents of the highest order), as extemporaneous effusions of his pen; and I have no doubt that the same epithet is still more literally applicable to his pulpit discourses. It is, indeed, only thus we can account for the variety and extent of his voluminous remains, when we recollect that the author died at the age of forty-six.[2]

To the extreme rapidity with which Barrow committed his thoughts to writing, I am inclined to ascribe the hasty and not altogether consistent opinions which he has hazarded on some important topics. I shall confine myself to a single example, which I select in preference to others, as it bears directly on the most interesting of all questions connected with the theory of morals. "If we scan," says he, "the particular nature, and search into the original causes of the several kinds of naughty dispositions in our souls, and of miscarriages in our lives, we shall find inordinate self-love to be a main ingredient, and a common source of them all; so that a divine of great name had some reason to affirm,—that *original sin* (or that innate distemper from which men generally become so very prone to evil, and averse to good), doth consist in self-love, disposing us to all kinds of irregularity and excess." In another passage, the same author expresses himself thus:—"Reason dictateth and prescribeth to us, that we should have a sober regard to our true good and welfare; to our best interests and solid content; to that which (all things being rightly stated, considered, and computed) will, in the final event, prove most beneficial and satisfactory to us: a self-love working in prosecution of such things, common sense cannot but allow and approve."

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[1] The *Intellectual System* was published in 1678. The *Treatise concerning Eternal and Immutable Morality* did not appear till a considerable number of years after the author's death.

[2] In a note annexed to an English translation of the Cardinal Maury's *Principles of Eloquence*, it is stated, upon the authority of a manuscript of Dr Doddridge, that *most* of Barrow's sermons were transcribed three times, and some much oftener. They seem to me to contain very strong intrinsic evidence of the incorrectness of this anecdote. Mr Abraham Hill, in his *Account of the Life of Barrow*, addressed to Dr Tillotson, contents himself with saying, that "*Some* of his sermons were written four or five times over;"—mentioning, at the same time, a circumstance which may account for this fact, in perfect consistency with what I have stated above,—that Barrow was very ready to *lend* his sermons as often as desired."

Of these two opposite and irreconcileable opinions, the latter is incomparably the least wide of the truth; and accordingly Mr Locke, and his innumerable followers, both in England and on the Continent, have maintained, that virtue and an enlightened self-love are one and the same. I shall afterwards find a more convenient opportunity for stating some objections to the latter doctrine, as well as to the former. I have quoted the two passages here, merely to show the very little attention that had been paid, at the era in question, to ethical science, by one of the most learned and profound divines of his age. This is the more remarkable, as his works everywhere inculcate the purest lessons of practical morality, and evince a singular acuteness and justness of eye in the observation of human character. Whoever compares the views of Barrow, when he touches on the theory of morals, with those opened about fifty years afterwards by Dr Butler, in his *Discourses on Human Nature*, will be abundantly satisfied, that, in this science, as well as in others, the progress of the philosophical spirit during the intervening period was not inconsiderable.

The name of Wilkins (although he too wrote with some reputation against the Epicureans of his day), is now remembered chiefly in consequence of his treatises concerning *a universal language and a real character*. Of these treatises, I shall hereafter have occasion to take some notice, under a different article. With all the ingenuity displayed in them, they cannot be considered as accessions of much value to science; and the long period since elapsed, during which no attempt has been made to turn them to any practical use, affords of itself no slight presumption against the solidity of the project.

A few years before the death of Hobbes, Dr Cumberland (afterwards Bishop of Peterborough) published a book, entitled, *De Legibus Naturæ, Disquisitio Philosophica;* the principal aim of which was to confirm and illustrate, in opposition to Hobbes, the conclusions of Grotius, concerning *Natural Law*. The work is executed with ability, and discovers juster views of the object of moral science, than any modern system that had yet appeared; the author resting the strength of his argument, not, as Grotius had done, on an accumulation of authorities, but on the principles of the human frame, and the mutual relations of the human race. The circumstance, however, which chiefly entitles this publication to *our* notice, is, that it seems to have been the earliest on the subject which attracted, in any considerable degree, the attention of English scholars. From this time, the writings of Grotius and of Puffendorff began to be generally studied, and soon after made their way into the Universities. In Scotland, the impression produced by them was more peculiarly remarkable. They were everywhere adopted as the best manuals of ethical and of political instruction that could be put into the hands of students, and gradually contributed to form that memorable school, from whence so many philosophers and philosophical historians were afterwards to proceed.

From the writings of Hobbes to those of Locke, the transition is easy and obvious; but before prosecuting farther the history of philosophy in England, it will be proper to turn our attention to its progress abroad, since the period at which this section commences.[1] In the first place, however, I shall add a few miscellaneous remarks on some important events which occurred in this country during the lifetime of Hobbes, and of which his extraordinary longevity prevented me sooner from taking notice.

Among these events, that which is most immediately connected with our present subject, is the establishment of the Royal Society of London in 1662, which was followed a few years afterwards by that of the Royal Academy of Sciences at Paris. The professed object of both institutions was the improvement of Experimental Knowledge, and of the auxiliary science of Mathematics; but their influence on the general progress of human reason has been far greater than could possibly have been foreseen at the moment of their foundation. On the happy effects resulting from them in this respect, La Place has introduced some just reflections in his *System of the World*, which, as they discover more originality of thought than he commonly displays, when he ventures to step beyond the circumference of his own magic circle, I shall quote, in a literal translation of his words.

" The chief advantage of learned societies, is the *philosophical spirit* to which they may be expected to give birth, and which they cannot fail to diffuse over all the various pursuits of the nations among whom they are established. The insulated scholar may without dread abandon himself to the spirit of system; he hears the voice of contradiction only from afar. But in a learned society, the collision of systematic opinions soon terminates in their common destruction; while the desire of mutual conviction creates among the members a tacit compact, to admit nothing but the results of observation, or the conclusions of mathematical reasoning. Accordingly, experience has shown, how much these establishments have contributed, since their origin, to the spread of true philosophy. By setting the example of submitting every thing to the examination of a severe logic, they have dissipated the prejudices which had too long reigned in the sciences, and which the strongest minds of the preceding centuries had not been able to resist. They have constantly opposed to empiricism a mass of knowledge, against which the errors adopted by the vulgar, with an enthusiasm which, in former times, would have perpetuated their empire, have spent their force in vain. In a word, it has been in their bosoms that those grand theories have been conceived, which, although far exalted by their generality above the reach of the multitude, are for this very reason entitled to special encouragement, from their innumerable applications to the phenomena of nature, and to the practice of the arts."[2]

In confirmation of these judicious remarks, it may be farther observed, that nothing could have been more happily imagined than the establishment of learned corporations for correcting those prejudices which (under the significant title of *Idola Specus)*, Bacon has described as incident to the retired student. While these *idols of the den* maintain their authority, the cultivation of the philosophical spirit is impossible; or rather, it is in a renunciation of this idolatry that the philosophical spirit essentially consists. It was accordingly in this great school of the learned world, that the characters of Bacon, Descartes, Leibnitz, and Locke were formed; the four individuals who have contributed the most to diffuse the philosophical spirit over Europe. The remark applies more peculiarly to Bacon, who first pointed out the inconveniences to be apprehended from a minute and mechanical subdivision of literary labour; and anticipated the advantages to be expected from the institution of learned academies, in enlarging the field of scientific curiosity, and the correspondent grasp of the emancipated mind. For accomplishing this object, what means so effectual as habits of daily intercourse with men whose pursuits are different from our own; and that expanded knowledge, both of man and of nature, of which such an intercourse must necessarily be productive!

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[1] Throughout the whole of this Discourse, I have avoided touching on the discussions which, on various occasions, have arisen with regard to the theory of government, and the comparative advantages or disadvantages of different political forms. Of the scope and spirit of these discussions it would be seldom possible to convey a just idea, without entering into details of a local or temporary nature, inconsistent with my general design. In the present circumstances of the world, besides, the theory of government (although, in one point of view, the most important of all studies) seems to possess a very subordinate interest to inquiries connected with political economy, and with the fundamental principles of legislation. What is it, indeed, that renders one form of government more favourable than another to human happiness, but the superior security it provides for the enactment of wise laws, and for their impartial and vigorous execution? These considerations will sufficiently account for my passing over in silence, not only the names of Needham, of Sidney, and of Milton, but that of Harrington, whose *Oceana* is justly regarded as one of the boasts of English literature, and is pronounced by Hume to be "the only valuable model of a commonwealth that has yet been offered to the public."—*Essays and Treatises*, Vol. I. Essay xvi.

A remark which Hume has elsewhere made on the *Oceana*, appears to me so striking and so instructive, that I shall give it a place in this note. " Harrington," he observes, " thought himself so sure of his general principle, *that the balance of power depends on that of property*, that he ventured to pronounce it impossible ever to re-establish monarchy in England: But his book was scarcely published when the King was restored; and we see that monarchy has ever since subsisted on the same footing as before. So dangerous is it for a politician to venture to foretell the situation of public affairs a few years hence."—*Ibid.* Essay vii.

How much nearer the truth, even in the science of *politics*, is Bacon's cardinal principle, that *knowledge* is power!—a principle, which applies to Man not less in his corporate than in his individual capacity; and which may be safely trusted to as the most solid of all foundations for our reasonings concerning the future history of the world.

[2] The Royal Society of London, though not incorporated by charter till 1662, may be considered as virtually existing, at least as far back as 1638, when some of the most eminent of the original members began first to hold regular meetings at Gresham College, for the purpose of philosophical discussion. Even these meetings were but a continuation of those previously held by the same individuals, at the apartments of Dr Wilkins in Oxford.—See SPRAT's *History of the Royal Society.*

Another event which operated still more forcibly and universally on the intellectual character of our countrymen, was the civil war which began in 1640, and which ultimately terminated in the usurpation of Cromwell. It is observed by Mr Hume, that " the prevalence of democratical principles, under the Commonwealth, engaged the country gentlemen to bind their sons apprentices to merchants; and that commerce has ever since been more honourable in England, than in any other European kingdom."[1] " The higher and the lower ranks (as a later writer has remarked) were thus brought closer together, and all of them inspired with an activity and vigour that, in former ages, had no example."[2]

To this combination of the pursuits of trade, with the advantages of a liberal education, may be ascribed the great multitude of ingenious and enlightened speculations on commerce, and on the other branches of national industry, which issued from the press, in the short interval between the Restoration and the Revolution; an interval during which the sudden and immense extension of the trade of England, and the corresponding rise of the commercial interest, must have presented a spectacle peculiarly calculated to awaken the curiosity of inquisitive observers. It is a very remarkable circumstance with respect to these economical researches, which now engage so much of the attention both of statesmen and of philosophers, that they are altogether of modern origin. " There is scarcely," says Mr Hume, " any ancient writer on politics who has made mention of trade; nor was it ever considered as an affair of state till the seventeenth century."[3]—The work of the celebrated John de Witt, entitled, " The true interest and political maxims of the republic of Holland and West Friesland," is the earliest publication of any note, in which commerce is treated of as an object of *national* and *political* concern, in opposition to the partial interests of corporations and of monopolists.

Of the English publications to which I have just alluded, the greater part consists of anonymous pamphlets, now only to be met with in the collections of the curious. A few bear the names of eminent English merchants. I shall have occasion to refer to them more particularly afterwards, when I come to speak of the writings of Smith, Quesnay, and Turgot. At present, I shall only observe, that, in these fugitive and now neglected tracts, are to be found the first rudiments of that science of *Political Economy*, which is justly considered as the boast of the present age; and which, although the aid of learning and philosophy was necessary to rear it to maturity, may be justly said to have had its cradle in the Royal Exchange of London.

Mr Locke was one of the first retired theorists (and this singular feature in his history has not been sufficiently attended to by his biographers), who condescended to treat of *trade* as an object of liberal study. Notwithstanding the manifold errors into which he fell in the course of his reasonings concerning it, it may be fairly questioned, if he has anywhere else given greater proofs, either of the vigour or of the originality of his genius. But the name of Locke reminds me, that it is now time to interrupt these national details, and to turn our attention to the progress of science on the Continent, since the times of Bodinus and of Campanella.

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[1] *History of England*, chap. lxii.
[2] CHALMERS's *Political Estimate*, &c. (London, 1804) p. 44.
[3] *Essay of Civil Liberty.*

SECTION II.

Progress of Philosophy in France during the Seventeenth Century.

MONTAIGNE—CHARRON—LA ROCHEFOUCAULD.

At the head of the French writers who contributed, in the beginning of the seventeenth century, to turn the thoughts of their countrymen to subjects connected with the Philosophy of Mind, Montaigne may, I apprehend, be justly placed. Properly speaking, he belongs to a period somewhat earlier; but his tone of thinking and of writing classes him much more naturally with his successors, than with any French author who had appeared before him.[1]

In assigning to Montaigne so distinguished a rank in the history of modern philosophy, I need scarcely say, that I leave entirely out of the account what constitutes (and justly constitutes) to the generality of readers the principal charm of his Essays; the good nature, humanity, and unaffected sensibility, which so irresistibly attach us to his character,—lending, it must be owned, but too often a fascination to his *talk*, when he cannot be recommended as the safest of companions. Nor do I lay much stress on the inviting frankness and vivacity with which he unbosoms himself about all his domestic habits and concerns, and which render his book so expressive a portrait, not only of the author, but of the Gascon country gentleman, two hundred years ago. I have in view chiefly the minuteness and good faith of his details concerning his own personal qualities, both intellectual and moral. The only study which seems ever to have engaged his attention was that of *man;* and for this he was singularly fitted, by a rare combination of that talent for observation which belongs to men of the world, with those habits of abstracted reflection, which men of the world have commonly so little disposition to cultivate. "I study myself," says he, "more than any other subject. This is my metaphysic; this my natural philosophy."[2] He has accordingly produced a work, *unique* in its kind; valuable, in an eminent degree, as an authentic record of many interesting facts relative to human nature; but more valuable by far, as holding up a mirror in which every individual, if he does not see his own image, will at least occasionally perceive so many traits of resemblance to it, as can scarcely fail to invite his curiosity to a more careful review of himself. In this respect, Montaigne's writings may be regarded in the light of what painters call *studies;* in other words, of those slight sketches which were originally designed for the improvement or amusement of the artist, but which, on that account, are the more likely to be useful in developing the germs of similar endowments in others.

Without a union of these two powers (reflection and observation), the study of Man can never be successfully prosecuted. It is only by retiring within ourselves that we can obtain a key to the characters of others; and it is only by observing and comparing the characters of others that we can thoroughly understand and appreciate our own.

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[1] Montaigne was born in 1533, and died in 1592.

[2] *Essays*, Book iii. chap. xiii.

After all, however, it may be fairly questioned, notwithstanding the scrupulous fidelity with which Montaigne has endeavoured to delineate his own portrait, if he has been always sufficiently aware of the secret folds and reduplications of the human heart. That he was by no means exempted from the common delusions of self-love and self-deceit, has been fully evinced in a very acute, though somewhat uncharitable, section of the *Port-Royal* logic; but this consideration, so far from diminishing the value of his Essays, is one of the most instructive lessons they afford to those who, after the example of the author, may undertake the salutary but humiliating task of self-examination.

As Montaigne's scientific knowledge was, according to his own account, "very vague and imperfect,"[1] and his book-learning rather sententious and gossiping, than comprehensive and systematical, it would be unreasonable to expect, in his philosophical arguments, much either of depth or of solidity.[2] The sentiments he hazards are to be regarded but as the impressions of the moment; consisting chiefly of the more obvious doubts and difficulties which, on all metaphysical and moral questions, are apt to present themselves to a speculative mind, when it first attempts to dig below the surface of common opinions. In reading Montaigne, accordingly, what chiefly strikes us, is not the novelty or the refinement of his ideas, but the liveliness and felicity with which we see embodied in words the previous wanderings of our own imaginations. It is probably owing to this circumstance, rather than to any direct plagiarism, that his Essays appear to contain the germs of so many of the paradoxical theories which, in later times, Helvetius and others have laboured to systematise and to support with the parade of metaphysical discussion. In the mind of Montaigne, the same paradoxes may be easily traced to those deceitful *appearances* which, in order to stimulate our faculties to their best exertions, nature seems purposely to have thrown in our way, as stumbling-blocks in the pursuit of truth; and it is only to be regretted on such occasions, for the sake of his own happiness, that his genius and temper qualified and disposed him more to start the problem than to investigate the solution.

When Montaigne touches on religion, he is, in general, less pleasing than on other subjects. His constitutional temper, it is probable, predisposed him to scepticism; but this original bias could not fail to be mightily strengthened by the disputes, both religious and political, which, during his lifetime, convulsed Europe, and more particularly his own country. On a mind like his it may be safely presumed, that the writings of the Reformers, and the instructions of Buchanan, were not altogether without effect; and hence, in all probability, the perpetual struggle, which he is at no pains to conceal, between the creed of his infancy, and the lights of his mature understanding. He speaks, indeed, of "reposing tranquilly on the *pillow of doubt*;" but this language is neither reconcileable with the general complexion of his works, nor with the most authentic accounts we have received of his dying moments. It is a maxim of his own, that, "in forming a judgment of a man's life, particular regard should be paid to his behaviour at the end of it;" to which he pathetically adds, "that the chief study of his own life was, that his latter end might be decent, calm, and silent." The fact is (if we may credit the testimony of his biographers), that, in his declining years, he exchanged his boasted *pillow of doubt* for the more powerful opiates prescribed by the infallible church; and that he expired in performing what his old preceptor Buchanan would not have scrupled to describe as an act of idolatry.[1]

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[1] Book i. chap. xxv.

[2] Montaigne's education, however, had not been neglected by his father. On the contrary, he tells us himself, that "George Buchanan, the great poet of Scotland, and Marcus Antonius Muretus, the best orator of his time, were among the number of his domestic preceptors."—"Buchanan," he adds, "when I saw him afterwards in the retinue of the late Mareschal de Brissac, told me, that he was about to write a treatise on the education of children, and that he would take the model of it from mine."—Book i. chap. xxv.

The scepticism of Montaigne seems to have been of a very peculiar cast, and to have had little in common with that either of Bayle or of Hume. The great aim of the two latter writers evidently was, by exposing the uncertainty of our reasonings whenever we pass the limit of sensible objects, to inspire their readers with a complete distrust of the human faculties on all moral and metaphysical topics. Montaigne, on the other hand, never thinks of forming a sect; but, yielding passively to the current of his reflections and feelings, argues, at different times, according to the varying state of his impressions and temper, on opposite sides of the same question. On all occasions, he preserves an air of the most perfect sincerity; and it was to *this*, I presume, much more than to the superiority of his reasoning powers, that Montesquieu alluded, when he said, " In the greater part of authors I see the *writer;* in Montaigne I see nothing but the *thinker*." The radical fault of his understanding consisted in an incapacity of forming, on disputable points, those decided and fixed opinions which can alone impart either force or consistency to intellectual character. For remedying this weakness, the religious controversies, and the civil wars recently engendered by the Reformation, were but ill calculated. The minds of the most serious men, all over Christendom, must have been then unsettled in an extraordinary degree; and where any predisposition to scepticism existed, every external circumstance must have conspired to cherish and confirm it. Of the extent to which it was carried, about the same period, in England, some judgment may be formed from the following description of a *Sceptic* by a writer not many years posterior to Montaigne.

" A sceptic in religion is one that hangs in the balance with all sorts of opinions; whereof not one but stirs him, and none sways him. A man guiltier of credulity than he is taken to be; for it is out of his belief of every thing that he believes nothing. Each religion scares him from its contrary, none persuades him to itself. He would be wholly a Christian, but that he is something of an Atheist; and wholly an Atheist, but that he is partly a Christian; and a perfect Heretic, but that there are so many to distract him. He finds *reason* in all opinions, *truth* in none; indeed, the least reason perplexes him, and the best will not satisfy him. He finds doubts and scruples better than resolves them, and *is always too hard for himself*."[2] If this portrait had been presented to Montaigne, I have little doubt that he would have had the candour to acknowledge, that he recognised in it some of the most prominent and characteristical features of his own mind.[3]

The most elaborate, and seemingly the most serious, of all Montaigne's essays, is his long and somewhat tedious *Apology for Raimond de Sebonde*, contained in the twelfth chapter of his second book. This author appears, from Montaigne's account, to have been a Spaniard, who professed physic at Thoulouse, towards the end of the fourteenth century; and who published a treatise, entitled, *Theologia Naturalis*, which was put into the hands of Montaigne's father by a friend, as a useful antidote against the innovations with which Luther was then beginning to disturb the ancient faith. That, in this particular instance, the book answered the intended purpose, may be presumed from the request of old Montaigne to his son, a few days before his death, to translate it into French from the Spanish original. His request was accordingly complied with; and the translation is referred to by Montaigne in the first edition of his *Essays*, printed at Bourdeaux in 1580; but the execution of this filial duty seems to have produced on Montaigne's own mind very different effects from what his father had anticipated.[1]

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[1] " Sentant sa fin approcher, il fit dire la messe dans sa chambre. A l'élévation de l'hostie, il se leva sur son lit pour l'adorer; mais une foiblesse l'enleva dans ce moment même, le 15 Septembre 1592, à 60 ans."—*Nouveau Dict. Histor.* à Lyon, 1804, Art. Montaigne.

[2] *Micro-cosmography, or a Piece of the World Discovered, in Essays and Characters.* For a short notice of the author of this very curious book (Bishop Earle), See the edition published at London in 1811. The chapter containing the above passage is entitled, *A Sceptic in Religion*; and it has plainly suggested to Lord Clarendon some of the ideas, and even expressions, which occur in his account of Chillingworth.

[3] " The writings of the best authors among the ancients," Montaigne tells us on one occasion, " being full and solid, tempt and carry me which way almost they will. He that I am reading seems always to have the most force; and I find that every one in turn has reason, though they contradict one another."—Book ii. chap. xii.

The principal aim of Sebonde's book, according to Montaigne, is to show that "Christians are in the wrong to make human reasoning the basis of their belief, since the object of it is only conceived by faith, and by a special inspiration of the divine grace." To this doctrine Montaigne professes to yield an implicit assent; and, under the shelter of it, contrives to give free vent to all the extravagances of scepticism. The essential distinction between the reason of man, and the instincts of the lower animals, is at great length, and with no inconsiderable ingenuity, disputed; the powers of the human understanding, in all inquiries, whether physical or moral, are held up to ridicule; an universal Pyrrhonism is recommended; and we are again and again reminded, that "*the senses are the beginning and the end of all our knowledge*." Whoever has the patience to peruse this chapter with attention, will be surprised to find in it the rudiments of a great part of the licentious philosophy of the eighteenth century; nor can he fail to remark the address with which the author avails himself of the language afterwards adopted by Bayle, Helvetius, and Hume:—"That, to be a philosophical sceptic, is the first step towards becoming a sound believing Christian."[2] It is a melancholy fact in ecclesiastical history, that this insidious maxim should have been sanctioned, in our times, by some theologians of no common pretensions to orthodoxy; who, in direct contradiction to the words of Scripture, have ventured to assert, that "he who comes to God must first believe that he is NOT." Is it necessary to remind these grave retailers of Bayle's sly and ironical sophistry, that every argument for Christianity, drawn from its *internal* evidence, tacitly recognises the authority of human reason; and assumes, as the ultimate *criteria* of truth and of falsehood, of right and of wrong, certain fundamental articles of belief, discoverable by the light of Nature?[5]

Charron is well known as the chosen friend of Montaigne's latter years, and as the confidential depositary of his philosophical sentiments. Endowed with talents far inferior in force and originality to those of his master, he possessed, nevertheless, a much sounder and more regulated judgment; and as his reputation, notwithstanding the liberality of some of his peculiar tenets, was high among the most respectable and conscientious divines of his own church, it is far from improbable, that Montaigne committed to him the guardianship of his posthumous fame, from motives similar to those which influenced Pope, in selecting Warburton as his literary executor. The discharge of this trust, however, seems to have done less good to Montaigne than harm to Charron; for while the unlimited scepticism, and the indecent levities

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The very few particulars known with respect to Sebonde have been collected by Bayle.—See his *Dictionary*, Art. Sebonde.

[2] This expression is Mr Hume's; but the same proposition, in substance, is frequently repeated by the two other writers, and is very fully enlarged upon by Bayle in the *Illustration upon the Sceptics*, annexed to his Dictionary.

[3] "I once asked *Adrian Turnebus*," says Montaigne, "what he thought of Sebonde's treatise. The answer he made to me was, That he believed it to be some extract from *Thomas Aquinas*, for that none but a genius like his was capable of such ideas."

I must not, however, omit to mention, that a very learned Protestant, *Hugo Grotius*, has expressed himself to his friend *Bignon* not unfavourably of Sebonde's intentions, although the terms in which he speaks of him are somewhat equivocal, and imply but little satisfaction with the execution of his design. "Non ignoras quantum excoluerint istam materiam *(argumentum scil. pro Religione Christiana) philosophica subtilitate* Raimundus Sebundus, dialogorum varietate Ludovicus Vives, maxima autem tum eruditione tum facundia vestras Philippus Mornæus." The authors of the *Nouveau Dictionnaire Historique* (Lyons, 1804) have entered much more completely into the spirit and drift of Sebonde's reasoning, when they observe, "Ce livre offre des singularités hardies, qui plurent dans le temps aux philosophes de ce siècle, et *qui ne déplairoient pas à ceux du notre*."

It is proper to add, that I am acquainted with Sebonde only through the *medium* of Montaigne's version, which does not lay claim to the merit of strict fidelity; the translator himself having acknowledged, that he had given to the Spanish philosopher "un accoutrement à la Françoise, et qu'il l'a dévêtu de son port farouche et maintien barbaresque, de manière qu'il a mes-hui assez de façon pour se présenter en toute bonne compagnie."

of the former, were viewed by the zealots of those days with a smile of tenderness and indulgence, the slighter heresies of the latter were marked with a severity the more rigorous and unrelenting, that, in points of essential importance, they deviated so very little from the standard of the Catholic faith. It is not easy to guess the motives of this inconsistency; but such we find from the fact to have been the temper of religious bigotry, or, to speak more correctly, of political religionism in all ages of the world.[1]

As an example of Charron's solicitude to provide an antidote against the more pernicious errors of his friend, I shall only mention his ingenious and philosophical attempt to reconcile, with the moral constitution of human nature, the apparent discordancy in the judgments of different nations concerning right and wrong. His argument on this point is in substance the very same with that so well urged by Beattie, in opposition to Locke's reasonings against the existence of innate practical principles. It is difficult to say, whether, in this instance, the coincidence between Montaigne and Locke, or that between Charron and Beattie, be the more remarkable.[2]

Although Charron has affected to give to his work a systematical form, by dividing and subdividing it into books and chapters, it is in reality little more than an unconnected series of essays on various topics, more or less distantly related to the science of Ethics. On the powers of the understanding he has touched but slightly; nor has he imitated Montaigne, in anatomizing, for the edification of the world, the peculiarities of his own moral character. It has probably been owing to the desultory and popular style of composition common to both, that so little attention has been paid to either by those who have treated of the history of French philosophy. To Montaigne's merits, indeed, as a lively and amusing essayist, ample justice has been done; but his influence on the subsequent habits of thinking among his countrymen remains still to be illustrated. He has done more, perhaps, than any other author (I am inclined to think with the most honest intentions), to introduce *into men's houses* (if I may borrow an expression of Cicero) what is now called the *new philosophy*,—a philosophy certainly very different from that of Socrates. In the fashionable world, he has, for more than two centuries, maintained his place as the first of moralists; a circumstance easily accounted for, when we attend to the singular combination, exhibited in his writings, of a semblance of erudition, with what Malebranche happily calls his *air du monde*, and *air cavalier*.[3] As for the graver and less attractive Charron, his name would probably before now have sunk into oblivion, had it not been so closely associated, by the accidental events of his life, with the more celebrated name of Montaigne.[4]

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[1] Montaigne, cet auteur charmant,
Tour-à-tour profond et frivole,
Dans son chateau paisiblement,
Loin de tout frondeur malévole,
Doutoit de tout impunément,
Et se moquoit très librement
Des bavards fourrés de l'école.
Mais quand son élève Charron,
Plus retenu, plus méthodique,
De sagesse donna leçon,
Il fut près de périr, dit-on,
Par la haine théologique.

VOLTAIRE, *Epître au Président Hénault.*

[2] See Beattie's *Essay on Fable and Romance;* and Charron *de la Sagesse*, Liv. ii. c. 8. It may amuse the curious reader also to compare the theoretical reasonings of Charron with a memoir in the *Phil. Trans.* for 1773, by Sir Roger Curtis, containing *some particulars with respect to the country of Labrador.*

[3] "Ah l'aimable homme, *qu'il est de bonne compagnie!* C'est mon ancien ami; mais, à force d'être ancien, il m'est nouveau."—MADAME DE SEVIGNÉ.

[4] Montaigne himself seems, from the general strain of his writings, to have had but little expectation of the posthumous fame which he has so long continued to enjoy. One of his reflections on this head is so characteristical of the author as a man, and, at the same time, affords so fine a specimen of the graphical powers of his now antiquated style, that I am tempted to transcribe it in his own words: "J'écris mon livre à peu d'hommes et à peu d'années; s'il ç'eût été une matière de durée, il l'eût fallu commettre à un langage plus ferme. Selon la variation continuelle qui a suivi le nôtre jusqu'à cette

The preceding remarks lead me, by a natural connection of ideas (to which I am here much more inclined to attend than to the order of dates), to another writer of the seventeenth century, whose influence over the literary and philosophical taste of France has been far greater than seems to be commonly imagined. I allude to the Duke of La Rochefoucauld, author of the *Maxims* and *Moral Reflections.*

Voltaire was, I believe, the first who ventured to assign to La Rochefoucauld the pre-eminent rank which belongs to him among the French classics. "One of the works," says he, "which contributed most to form the taste of the nation to a justness and precision of thought and expression, was the small collection of maxims by Francis Duke of La Rochefoucauld. Although there be little more than one idea in the book, that *self-love is the spring of all our actions*, yet this idea is presented in so great a variety of forms, as to be always amusing. When it first appeared, it was read with avidity; and it contributed, more than any other performance, since the revival of letters, to improve the vivacity, correctness, and delicacy of French composition."

Another very eminent judge of literary merit (the late Dr Johnson) was accustomed to say of La Rochefoucauld's *Maxims*, that it was almost the only book written by a man of fashion, of which professed authors had reason to be jealous. Nor is this wonderful, when we consider the unwearied industry of the very accomplished writer, in giving to every part of it the highest and most finished polish which his exquisite taste could bestow. When he had committed a maxim to paper, he was in use to circulate it among his friends, that he might avail himself of their critical animadversions; and, if we may credit Segrais, altered some of them no less than thirty times, before venturing to submit them to the public eye.

That the tendency of these maxims is, upon the whole, unfavourable to morality, and that they always leave a disagreeable impression on the mind, must, I think, be granted. At the same time, it may be fairly questioned, if the motives of the author have in general been well understood, either by his admirers or his opponents. In affirming that self-love is the spring of all our actions, there is no good reason for supposing that he meant to deny the reality of moral distinctions as a philosophical truth;—a supposition quite inconsistent with his own fine and deep remark, that *hypocrisy is itself an homage which vice renders to virtue.* He states it merely as a position which, in the course of his experience as a man of the world, he had found very generally verified in the higher classes of society, and which he was induced to announce without any qualification or restriction, in order to give more force and poignancy to his satire In adopting this mode of writing, he has unconsciously conformed himself, like many other French authors, who have since followed his example, to a suggestion which Aristotle has stated with admirable depth and acuteness in his Rhetoric. "Sentences or apophthegms lend much aid to eloquence. One reason of this is, that they flatter the *pride* of the hearers, who are delighted when the speaker, making use of general language, touches upon opinions which they had before known to be true in part. Thus, a person who had the misfortune to live in a bad neighbourhood, or to have worthless children, would easily assent to the speaker who should affirm, that *nothing* is more vexatious than to have any neighbours; *nothing* more irrational than to bring children into the world."[1] This observation of Aristotle, while it goes far to account for the imposing and dazzling effect of these rhetorical exaggerations, ought to guard us against the common and popular error of mis-

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heure, qui peut espérer que sa forme présente soit en usage d'ici à cinquante ans? il écoule tous les jours de nos mains, et depuis que je vis s'est altéré de moitié. Nous disons qu'il est à cette heure parfait: Autant en dit du sien chaque siècle. *C'est aux bons et utiles écrits de le clouer à eux, et ira sa fortune selon le crédit de notre état.*"

How completely have both the predictions in the last sentence been verified by the subsequent history of the French language!

[1] Ἔχουσι δὲ (γνῶμαι) εἰς τοὺς λόγους βοήθειαν μεγάλην, μίαν μὲν δὴ, διὰ τὴν φορτικότητα τῶν ἀκροατῶν· χαίρουσι γὰρ, ἐάν τις καθόλου λέγων, ἐπιτύχῃ τῶν δοξῶν, ἃς ἐκεῖνοι κατὰ μέρος ἔχουσι.—Ἡ μὲν γὰρ γνώμη, ὥσπερ ἐίρηται, καθόλου ἀποφανσίς ἐστι· χαίρουσι δὲ καθόλου λεγομένου, ὃ κατὰ μέρος προϋπολαμβάνοντες τυγχάνουσι· οἷον, ἐί τις γείτοσι τύχῃ κεχρημένος ἢ τέκνοις φαύλοις, ἀποδέξαιτ᾽ ἂν τοῦ εἰπόντος, οὐδὲν γειτονίας χαλεπώτερον· ἢ, ὅτι οὐδὲν ἠλιθιώτερον τεκνοποῖας.—Arist. *Rhet.* Lib. ii. c. xxi.

The whole chapter is interesting and instructive, and shows how profoundly Aristotle had meditated the principles of the rhetorical art.

taking them for the serious and profound generalisations of science. As for La Rochefoucauld, we know, from the best authorities, that, in private life, he was a conspicuous example of all those moral qualities of which he seemed to deny the existence; and that he exhibited, in this respect, a striking contrast to the Cardinal de Retz, who has presumed to censure him for his want of faith in the reality of virtue.

In reading La Rochefoucauld, it should never be forgotten, that it was within the vortex of a court he enjoyed his chief opportunities of studying the world; and that the narrow and exclusive circle in which he moved was not likely to afford him the most favourable specimens of human nature in general. Of the Court of Lewis XIV. in particular, we are told by a very nice and reflecting observer (Madame de la Fayette), that "ambition and gallantry were *the soul*, actuating alike both men and women. So many contending interests, so many different cabals were constantly at work, and in all of these, women bore so important a part, that love was always mingled with business, and business with love. Nobody was tranquil or indifferent. Every one studied to advance himself by pleasing, serving, or ruining others. Idleness and languor were unknown, and nothing was thought of but intrigues or pleasures."

In the passage already quoted from Voltaire, he takes notice of the effect of La Rochefoucauld's Maxims, in improving the style of French composition. We may add to this remark, that their effect has not been less sensible in vitiating the tone and character of French philosophy, by bringing into vogue those false and degrading representations of human nature and of human life, which have prevailed in that country, more or less, for a century past. Mr Addison, in one of the papers of the *Tatler*, expresses his indignation at this general bias among the French writers of his age. "It is impossible," he observes, "to read a passage in Plato or Tully, and a thousand other ancient moralists, without being a greater and better man for it. On the contrary, I could never read any of our modish French authors, or those of our own country, who are the imitators and admirers of that nation, without being, for some time, out of humour with myself, and at every thing about me. Their business is to depreciate human nature, and to consider it under the worst appearances; they give mean interpretations and base motives to the worthiest actions. In short, they endeavour to make no distinction between man and man, or between the species of man and that of the brutes."[1]

It is very remarkable, that the censure here bestowed by Addison on the fashionable French wits of his time should be so strictly applicable to Helvetius, and to many others of the most admired authors whom France has produced in our own day. It is still more remarkable to find the same depressing spirit shedding its malignant influence on French literature, as early as the time of La Rochefoucauld, and even of Montaigne; and to observe how very little has been done by the successors of these old writers, but to expand into grave philosophical systems their loose and lively paradoxes; disguising and fortifying them by the aid of those logical principles, to which the name and authority of Locke have given so wide a circulation in Europe.

In tracing the origin of that false philosophy on which the excesses of the French revolutionists have entailed such merited disgrace, it is usual to remount no higher than to the profligate period of the Regency; but the seeds of its most exceptionable doctrines had been sown in that country at an earlier era, and were indebted for the luxuriancy of their harvest, much more to the political and religious soil where they struck their roots, than to the skill or foresight of the individuals by whose hands they were scattered.

I have united the names of Montaigne and of La Rochefoucauld, because I consider their writings as rather addressed to the world at large, than to the small and select class of speculative students. Neither of them can be said to have enriched the stock of human knowledge by the addition of any one important general conclusion; but the maxims of both have operated very extensively and powerfully on the taste and principles of the higher orders all over Europe, and predisposed them to give a welcome reception to the same ideas, when afterwards reproduced with the imposing appendage of logical method, and of a technical phraseology. The foregoing reflections, therefore, are not so foreign as might at first be apprehended, to the subsequent history of ethical and of metaphysical speculation. It is time, however, now to turn our attention to a subject far more intimately connected with the general progress of human reason,—the philosophy of Descartes.

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[1] *Tatler*, No. 103. The last paper of the *Tatler* was published in 1711; and, consequently, the above passage must be understood as referring to the *modish* tone of French philosophy prior to the death of Louis XIV.

DESCARTES—GASSENDI—MALEBRANCHE.

According to a late writer,[1] whose literary decisions (excepting where he touches on religion or politics) are justly entitled to the highest deference, Descartes has a better claim than any other individual, to be regarded as the father of that spirit of free inquiry, which in modern Europe has so remarkably displayed itself in all the various departments of knowledge. Of Bacon, he observes, " that though he possessed, in a most eminent degree, the genius of philosophy, he did not unite with it the genius of the sciences; and that the methods proposed by him for the investigation of truth, consisting entirely of precepts which he was unable to exemplify, had little or no effect in accelerating the rate of discovery." As for Galileo, he remarks, on the other hand, " that his exclusive taste for mathematical and physical researches, disqualified him for communicating to the general mind that impulse of which it stood in need."

" This honour," he adds, " was reserved for Descartes, who combined in himself the characteristical endowments of both his predecessors. If, in the physical sciences, his march be less sure than that of Galileo—if his logic be less cautious than that of Bacon—yet the very temerity of his errors was instrumental to the progress of the human race. He gave activity to minds which the circumspection of his rivals could not awake from their lethargy. He called upon men to throw off the yoke of authority, acknowledging no influence but what reason should avow: And his call was obeyed by a multitude of followers, encouraged by the boldness, and fascinated by the enthusiasm of their leader."

In these observations, the ingenious author has rashly generalised a conclusion deduced from the literary history of his own country. That the works of Bacon were but little read there till after the publication of D'Alembert's Preliminary Discourse, is, I believe, an unquestionable fact;[2] *not* that it necessarily follows from this, that, even in France, no previous effect had been produced by the labours of Boyle, of Newton, and of the other English experimentalists, trained in Bacon's school. With respect to England, it is a fact not less certain, that at no period did the philosophy of Descartes produce such an impression on public opinion, either in Physics or in Ethics, as to give the slightest colour to the supposition, that it contributed, in the most distant degree, to the subsequent advances made by our countrymen in these sciences. In Logic and Metaphysics, indeed, the case was different. Here the writings of Descartes did much; and if they had been studied with proper attention, they might have done much more. But of *this* part of their merits, Condorcet seems to have had no idea. His eulogy, therefore, is rather misplaced than excessive. He has extolled Descartes as the father of Experimental Physics: He would have been nearer the truth, if he had pointed him out as the father of the Experimental Philosophy of the Human Mind.

In bestowing this title on Descartes, I am far from being inclined to compare him, in the number or importance of *the facts* which he has remarked concerning our intellectual powers, to various other writers of an earlier date. I allude merely to his clear and precise conception of that operation of the understanding (distinguished afterwards in Locke's *Essay* by the name of *Reflection)*, through the medium of which all our knowledge of Mind is exclusively to be obtained. Of the essential subserviency of this power to every satisfactory conclusion that can be formed with respect to the mental phenomena, and of the futility of every theory which would attempt to explain them by metaphors borrowed from the material world, no other philosopher prior to Locke seems to have been fully aware; and from the moment that these truths were recognised as logical principles in the study of *mind*, a new era commences in the history of that branch of science. It will be necessary, therefore, to allot to the illustration of this part of the Cartesian philosophy a larger space than the limits of my undertaking will permit me to afford to the researches of some succeeding inquirers, who may, at first sight, appear more worthy of attention in the present times.

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[1] Condorcet.

[2] One reason for this is well pointed out by D'Alembert. "Il n'y a que les chefs de secte en tout genre, dont les ouvrages puissent avoir un certain éclat; Bacon n'a pas été du nombre, et la forme de sa philosophie s'y opposoit: elle étoit trop sage pour étonner personne."—*Disc. Prel.*

It has been repeatedly asserted by the Materialists of the last century, that Descartes was the first Metaphysician by whom the pure immateriality of the human soul was taught; and that the ancient philosophers, as well as the schoolmen, went no farther than to consider *mind* as the result of a material organisation, in which the constituent elements approached to evanescence in point of subtlety. Both of these propositions I conceive to be totally unfounded. That many of the schoolmen, and that the wisest of the ancient philosophers, when they described the mind as a *spirit*, or as a *spark of celestial fire*, employed these expressions, *not* with any intention to materialise its essence, but merely from want of more unexceptionable language, might be shown with demonstrative evidence, if this were the proper place for entering into the discussion. But what is of more importance to be attended to, on the present occasion, is the effect of Descartes' writings in disentangling the *logical principle* above mentioned, from the *scholastic* question about the nature of *mind*, as contradistinguished from *matter*. It were indeed to be wished, that he had perceived still more clearly and steadily the essential importance of keeping this distinction constantly in view; but he had at least the merit of illustrating, by his own example, in a far greater degree than any of his predecessors, the possibility of studying the mental phenomena, without reference to any facts but those which rest on the evidence of consciousness. The metaphysical question about the *nature* of mind he seems to have considered as a problem, the solution of which was an easy corollary from these *facts*, if distinctly apprehended; but still as a problem, whereof it was possible that different views might be taken by those who agreed in opinion, as far as *facts* alone were concerned. Of this a very remarkable example has since occurred in the case of Mr Locke, who, although he has been at great pains to show, that the power of *reflection* bears the same relation to the study of the mental phenomena, which the power of *observation* bears to the study of the material world, appears, nevertheless, to have been far less decided than Descartes with respect to the essential distinction between Mind and Matter; and has even gone so far as to hazard the unguarded proposition, that there is no absurdity in supposing the Deity to have superadded to the other qualities of matter *the power of thinking*. His scepticism, however, on this point, did not prevent his good sense from perceiving, with the most complete conviction, the indispensable necessity of abstracting from the analogy of matter, in studying the laws of our intellectual frame.

The question about the nature or essence of the soul, has been, in all ages, a favourite subject of discussion among Metaphysicians, from its supposed connection with the argument in proof of its immortality. In this light it has plainly been considered by both parties in the dispute; the one conceiving, that if Mind could be shown to have no quality in common with Matter, its *dissolution* was physically impossible; the other, that if this assumption could be disproved, it would necessarily follow, that the *whole man* must perish at death. For the last of these opinions Dr Priestley and many other speculative theologians have of late very zealously contended; flattering themselves, no doubt, with the idea, that they were thus preparing a triumph for their own peculiar schemes of Christianity. Neglecting, accordingly, all the presumptions for a future state, afforded by a comparison of the course of human affairs with the moral judgments and moral feelings of the human heart; and overlooking, with the same disdain, the presumptions arising from the narrow sphere of human knowledge, when compared with the indefinite improvement of which our intellectual powers seem to be susceptible, this acute but superficial writer attached himself exclusively to the old and hackneyed pneumatological argument; tacitly assuming as a principle, that the future prospects of man depend entirely on the determination of a *physical* problem, analogous to that which was then dividing chemists about the existence or non-existence of Phlogiston. In the actual state of science, these speculations might well have been spared. Where is the sober metaphysician to be found, who now speaks of the immortality of the soul as a logical consequence of its immateriality; instead of considering it as depending on the will of that Being by whom it was at first called into existence? And, on the other hand, is it not universally admitted by the best philosophers, that whatever hopes the light of nature encourages beyond the present scene, rest solely (like all our other anticipations of future events) on the general tenor and analogy of the laws by which we perceive the universe to be governed? The proper use of the argument concerning *the immateriality of mind*, is not to establish any positive conclusion as to its destiny hereafter; but to repel the reasonings alleged by materialists, as proofs that its annihilation must be the obvious and necessary effect of the dissolution of the body.[1]

I thought it proper to state this consideration pretty fully, lest it should be supposed that the logical method recommended by Descartes for studying the phenomena of mind, has any necessary dependence on his metaphysical opinion concerning its being and properties, as a separate substance.[2] Between these two parts of his system, however, there is, if not a demonstrative connection, at least a natural and manifest affinity; inasmuch as a steady adherence to his logical method (or, in other words, the habitual exercise of patient *reflection*), by accustoming us to break asunder the obstinate associations to which materialism is indebted for the early hold it is apt to take of the fancy, gradually and insensibly predisposes us in favour of his metaphysical conclusion. It is to be regretted, that, in stating this conclusion, his commentators should so frequently make use of the word *spirituality;* for which I do not recollect that his own works afford any authority. The proper expression is *immateriality*, conveying merely a negative idea; and, of consequence, implying nothing more than a rejection of that hypothesis concerning the nature of Mind, which the scheme of materialism so gratuitously, yet so dogmatically assumes.[3]

The power of Reflection, it is well known, is the last of our intellectual faculties that unfolds itself; and, in by far the greater number of individuals, it never unfolds itself in any considerable degree. It is a fact equally certain, that, long before the period of life when this power begins to exercise its appropriate functions, the understanding is already preoccupied with a chaos of opinions, notions, impressions, and associations, bearing on the most important objects of human inquiry; not to mention the innumerable sources of illusion and error connected with the use of a vernacular language, learned in infancy by rote, and identified with the first processes of thought and perception. The consequence is, that when man begins to reflect, he finds himself (if I may borrow an allusion of M. Turgot's) lost in a labyrinth, into which he had been led blindfold.[1] To the same purpose, it was long ago complained of by Bacon, " that no one has yet been found of so constant and severe a mind, as to have determined and tasked himself utterly to abolish theories and common notions, and to apply his intellect, altogether smooth and even, to particulars anew. Accordingly, that human reason which we have, is a kind of medley and unsorted collection, from much trust and much accident, and the childish notions which we first drank in. Whereas, if one of ripe age and sound senses, and a mind thoroughly cleared, should apply himself freshly to experiment and particulars, of him were better things to be hoped."

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[1] "We shall here be content," says the learned John Smith of Cambridge, "with that sober thesis of Plato, in his *Timæus*, who attributes the perpetuation of all substances to the benignity and liberality of the Creator; whom he therefore brings in thus speaking, ὑμεῖς οὐκ ἐστε ἀθάνατοι οὐδὲ ἄλυτοι, κ. τ. λ. *You are not of yourselves immortal nor indissoluble, but would relapse and slide back from that being which I have given you, should I withdraw the influence of my own power from you; but yet you shall hold your immortality by a patent from myself.*"—(*Select Discourses*, Cambridge, 1660.) I quote this passage from one of the oldest partisans of Descartes among the English philosophers.

Descartes himself is said to have been of a different opinion. "On a été étonné," says Thomas, "que dans ses *Méditations Métaphysiques*, Descartes n'ait point parlé de l'immortalité de l'âme. Mais il nous apprend lui-même par une de ses lettres, qu'ayant établi clairement, dans cet ouvrage, la distinction de l'âme et de la matière, il suivoit nécessairement de cette distinction, que l'âme par sa nature ne pouvoit périr avec le corps."—*Eloge de Descartes.* Note 21.

[2] I employ the scholastic word *substance*, in conformity to the phraseology of Descartes; but I am fully aware of the strong objections to which it is liable, not only as a wide deviation from popular use, which has appropriated it to things material and tangible, but as implying a greater degree of positive knowledge concerning the nature of *mind*, than our faculties are fitted to attain.—For some further remarks on this point, See Note I.

[3] See Note K.

What Bacon has here recommended, Descartes attempted to execute; and so exact is the coincidence of his views on this fundamental point with those of his predecessor, that it is with difficulty I can persuade myself that he had never read Bacon's works.[2] In the prosecution of this undertaking, the first steps of Descartes are peculiarly interesting and instructive; and it is *these* alone which merit our attention at present. As for the details of his system, they are now curious only as exhibiting an amusing contrast to the extreme rigour of the principle from which the author sets out; a contrast so very striking, as fully to justify the epigrammatic saying of D'Alembert, that " Descartes began with doubting of every thing, and ended in believing that he had left nothing unexplained."

Among the various articles of common belief which Descartes proposed to subject to a severe scrutiny, he enumerates particularly, the conclusiveness of mathematical demonstration; the existence of God; the existence of the material world; and even the existence of his own body. The only thing that appeared to him certain and incontrovertible, was his own existence; by which he repeatedly reminds us, we are to understand merely the existence of *his mind*, abstracted from all consideration of the material organs connected with it. About every other proposition, he conceived, that doubts might reasonably be entertained; but to suppose the non-existence of *that* which thinks, at the very moment it is conscious of thinking, appeared to him a contradiction in terms. From this single postulatum, accordingly, he took his departure; resolved to admit nothing as a philosophical truth, which could not be deduced from it by a chain of logical reasoning.[3]

Having first satisfied himself of his own existence, his next step was to inquire, how far his perceptive and intellectual faculties were entitled to credit. For this purpose, he begins with offering a proof of the existence and attributes of God;—truths which he conceived to be necessarily involved in the idea he was able to form of a perfect, self-existent, and eternal being. His reasonings on this point it would be useless to state. It is sufficient to observe, that they led him to conclude, that God cannot possibly be supposed to deceive his creatures; and therefore, that the intimations of our senses, and the decisions of our reason, are to be trusted to with entire confidence, wherever they afford us *clear and distinct ideas* of their respective objects.[4]

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[1] " Quand l'homme a voulu se replier sur lui-même, il s'est trouvé dans un labyrinthe, où il étoit entré les yeux bandés."—*Œuvres de Turgot*, Tom. II. p. 261.

[2] See Note L.

[3] " Sic autem rejicientes illa omnia, de quibus aliquo modo possumus dubitare, ac etiam falsa esse fingentes, facile quidem supponimus nullum esse Deum, nullum cœlum, nulla corpora; nosque etiam ipsos, non habere manus, nec pedes, nec denique ullum corpus: non autem ideo nos qui talia cogitamus nihil esse: repugnat enim, ut putemus id quod cogitat, eo ipso tempore quo cogitat, non existere. Ac proinde hæc cognitio, *ego cogito, ergo sum*, est omnium prima et certissima, quæ cuilibet ordine philosophanti occurrat."—*Princip. Philos.* Pars I. § 7.

[4] The substance of Descartes' argument on these fundamental points, is thus briefly recapitulated by himself in the conclusion of his third Meditation:—" Dum in meipsum mentis aciem converto, non modo intelligo me esse rem incompletam, et ab alio dependentem, remque ad majora et meliora indefinite aspirantem, sed simul etiam intelligo illum, a

As Descartes conceived the existence of God (next to the existence of his own mind) to be the most indisputable of all truths, and rested his confidence in the conclusions of human reason entirely on his faith in the divine veracity, it is not surprising that he should have rejected the argument from *final causes*, as superfluous and unsatisfactory. To have availed himself of its assistance would not only have betrayed a want of confidence in what he professed to regard as much more certain than any mathematical theorem; but would obviously have exposed him to the charge of first appealing to the divine attributes in proof of the authority of his faculties; and afterwards, of appealing to these faculties, in proof of the existence of God.

It is wonderful that it should have escaped the penetration of this most acute thinker, that a *vicious circle* of the same description is involved in every appeal to the intellectual powers, in proof of their own credibility; and that unless this credibility be assumed as unquestionable, the farther exercise of human reason is altogether nugatory. The evidence for the existence of God seems to have appeared to Descartes too irresistible and overwhelming, to be subjected to those logical canons which apply to all the other conclusions of the understanding.[1]

Extravagant and hopeless as these preliminary steps must now appear, they had nevertheless an obvious tendency to direct the attention of the author, in a singular degree, to the phenomena of thought; and to train him to those habits of abstraction from external objects, which, to the bulk of mankind, are next to impossible. In this way he was led to perceive, with the evidence of consciousness, that the attributes of Mind were still more clearly and distinctly knowable than those of Matter; and that, in studying the former, so far from attempting to explain them by analogies borrowed from the latter, our chief aim ought to be, to banish as much as possible from the fancy every analogy, and even every analogical expression, which, by inviting the attention abroad, might divert it from its proper business at home. In one word, that the only right method of philosophising on this subject was comprised in the old stoical precept (understood in a sense somewhat different from that originally annexed to it) *nec te quæsiveris extra*. A just conception of this rule, and a steady adherence to its spirit, constitutes the ground-work of what is properly called the Experimental Philosophy of the Human Mind. It is thus that all our facts relating to Mind must be ascertained; and it is only upon facts thus attested by our own consciousness, that any just theory of Mind can be reared.

Agreeably to these views, Descartes was, I think, the first who clearly saw that our idea of Mind is not direct, but relative;—relative to the various operations of which we are conscious. What am I? he asks, in his second Meditation: A thinking being,—that is, a being doubting,

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quo pendeo, majora ista omnia non indefinite et potentia tantum, sed reipsa infinite in se habere, atque ita Deum esse; totaque vis argumenti in eo est, quod agnoscam fieri non posse ut existam talis naturæ qualis sum, nempe ideam Dei in me habens, nisi revera Deus etiam existeret, Deus, inquam, ille idem cujus idea in me est, hoc est, habens omnes illas perfectiones quas ego non comprehendere, sed quocunque modo attingere cogitatione possum, et nullis plane defectibus obnoxius. Ex his satis patet, illum fallacem esse non posse: omnem enim fraudem et deceptionem a defectu aliquo pendere lumine naturali manifestum est."

The above argument for the existence of God (very improperly called by some foreigners an argument *a priori*), was long considered by the most eminent men in Europe as quite demonstrative. For my own part, although I do not think that it is by any means so level to the apprehension of common inquirers, as the argument from the marks of *design* everywhere manifested in the universe, I am still less inclined to reject it as altogether unworthy of attention. It is far from being so metaphysically abstruse as the reasonings of Newton and Clarke, founded on our conceptions of *space* and of *time*; nor would it appear, perhaps, less logical and conclusive than that celebrated demonstration, if it were properly unfolded, and stated in more simple and popular terms. The two arguments, however, are in no respect exclusive of each other; and I have always thought, that, by combining them together, a proof of the point in question might be formed, more impressive and luminous than is to be obtained from either, when stated apart.

[1] How painful is it to recollect, that the philosopher who had represented his faith in the veracity of God, as the sole foundation of his confidence in the demonstrations of mathematics, was accused and persecuted by his contemporaries as an atheist; and *that*, too, in the same country (Holland), where, for more than half a century after his death, his doctrines were to be taught in all the universities with a blind idolatry! A zeal without knowledge, and the influence of those earthly passions, from which even Protestant divines are not always exempted, may, it is to be hoped, go far to account for this inconsistency and injustice, without adopting the uncharitable insinuation of D'Alembert: "Malgré toute la sagacité qu'il avoit employée pour prouver l'existence de Dieu, il fut accusé de la nier par *des ministres, qui peut-être ne la croyoient pas*."

knowing, affirming, denying, consenting, refusing, susceptible of pleasure and of pain.[1] Of all these things I might have had complete experience, without any previous acquaintance with the qualities and laws of matter; and therefore it is impossible that the study of matter can avail me aught in the study of myself. This, accordingly, Descartes laid down as a first principle, that *nothing comprehensible by the imagination can be at all subservient to the knowledge of Mind;* and that the sensible images involved in all our common forms of speaking concerning its operations, are to be guarded against with the most anxious care, as tending to confound, in our apprehensions, two classes of phenomena, which it is of the last importance to distinguish accurately from each other.[2]

To those who are familiarly acquainted with the writings of Locke, and of the very few among his successors who have thoroughly entered into the spirit of his philosophy, the foregoing observations may not appear to possess much either of originality or of importance; but when first given to the world, they formed the greatest step ever made in the science of Mind, by a single individual. What a contrast do they exhibit, not only to the discussions of the schoolmen, but to the analogical theories of Hobbes at the very same period! and how often have they been since lost sight of, notwithstanding the clearest speculative conviction of their truth and importance, by Locke himself, and by the greatest part of his professed followers! Had they been duly studied and understood by Mr Horne Tooke, they would have furnished him with a key for solving those etymological riddles, which, although mistaken by many of his contemporaries for profound philosophical discoveries, derive, in fact, the whole of their mystery, from the strong bias of shallow reasoners to *relapse* into the same scholastic errors, from which Descartes, Locke, Berkeley, Hume, and Reid, have so successfully laboured to emancipate the mind.

If any thing can add to our admiration of a train of thought manifesting in its author so unexampled a triumph over the strongest prejudices of sense, it is the extraordinary circumstance of its having first occurred to a young man, who had spent the years commonly devoted to academical study, amid the dissipation and tumult of camps.[3] Nothing could make this conceivable, but the very liberal education which he had previously received under the Jesuits, at the college of *La Flèche;*[4] where, we are told, that while yet a boy, he was so distinguished by habits of deep meditation, that he went among his companions by the name of *the Philosopher*. Indeed, it is only at that early age, that such habits are to be cultivated with complete success.

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[1] "Non sum compages illa membrorum, quæ corpus humanum appellatur; non sum etiam tenuis aliquis aër istis membris infusus; non ventus, non ignis, non vapor, non halitus——Quid igitur sum? res cogitans; quid est hoc? nempe dubitans, intelligens, affirmans, negans, volens, nolens," &c.—*Med. Sec.*

[2] "Itaque cognosco, nihil eorum quæ possum *Imaginatione* comprehendere, ad hanc quam de me habeo notitiam pertinere; mentemque ab illis diligentissime esse avocandam, ut suam ipsa naturam quam distinctissime percipiat.—*Ibid.* A few sentences before, Descartes explains with precision in what sense *Imagination* is here to be understood. "Nihil aliud est *imaginari* quam rei corporeæ figuram seu imaginem contemplari."

The following extracts from a book published at Cambridge in 1660 (precisely ten years after the death of Descartes), while they furnish a useful comment on some of the above remarks, may serve to show, how completely the spirit of the Cartesian philosophy of Mind had been seized even *then*, by some of the members of that university.

"The souls of men exercising themselves first of all *κίνησει προβατικῇ*, as the Greek philosopher expresseth himself, merely by a *progressive kind of motion*, spending themselves about bodily and material acts, and conversing only with sensible things; they are apt to acquire such deep stamps of material phantasms to themselves, that they cannot imagine their own *Being* to be any other than *material* and *divisible*, though of a fine ethereal nature. It is not possible for us well to know what our souls are, but only by their *κίνησεις κυκλίκαι*, their *circular or reflex motions*, and converse with themselves, which can only steal from them their own secrets."—Smith's *Select Discourses*, p. 65, 66.

"If we reflect but upon our own souls, how manifestly do the notions of *reason*, *freedom*, *perception*, and the like, offer themselves to us, whereby we may *know* a thousand times *more distinctly* what our souls are than what our bodies are. For the former, we know by an immediate converse with ourselves, and a distinct sense of their operations; whereas all our knowledge of the body is little better than merely historical, which we gather up by scraps and piecemeal, from more doubtful and uncertain experiments which we make of them; but the notions which we have of a *mind*, *i. e.* something within us that thinks, apprehends, reasons, and discourses, are so clear and distinct from all those notions which we can fasten upon a body, that we can easily conceive that if all *body-being* in the world were destroyed, yet we might then as well subsist as now we do."—*Ibid.* p. 98.

[3] "Descartes porta les armes, d'abord en Hollande, sous le célèbre Maurice de Nassau; de-là en Allemagne, sous Maximilien de Bavière, au commencement de la guerre de trente ans. Il passa ensuite au service de l'Empereur Ferdinand II. pour voir de plus près les troubles de la Hongrie. On croit aussi, qu'au siège de la Rochelle, il combattit, comme volontaire, dans une bataille contre la flotte Angloise."—Thomas, *Eloge de Descartes*, Note 8.

When Descartes quitted the profession of arms, he had arrived at the age of twenty-five.

[4] It is a curious coincidence, that it was in the same village of *La Flèche* that Mr Hume fixed his residence, while com-

The glory, however, of having pointed out to his successors the true method of studying the theory of *Mind*, is almost all that can be claimed by Descartes in logical and metaphysical science. Many important hints, indeed, may be gleaned from his works; but, on the whole, he has added very little to our knowledge of human nature. Nor will this appear surprising, when it is recollected, that he aspired to accomplish a similar revolution in all the various departments of physical knowledge;—not to mention the time and thought he must have employed in those mathematical researches, which, however lightly esteemed by himself, have been long regarded as the most solid basis of his fame.[1]

Among the principal articles of the Cartesian philosophy, which are now incorporated with our prevailing and most accredited doctrines, the following seem to me to be chiefly entitled to notice:

1. His luminous exposition of the common logical error of attempting to define words which express notions too simple to admit of analysis. Mr Locke claims this improvement as entirely his own; but the merit of it unquestionably belongs to Descartes, although it must be owned that he has not always sufficiently attended to it in his own researches.[2]

2. His observations on the different classes of our prejudices—particularly on the errors to which we are liable in consequence of a careless use of language as the instrument of thought. The greater part of these observations, if not the whole, had been previously hinted at by Bacon; but they are expressed by Descartes with greater precision and simplicity, and in a style better adapted to the taste of the present age.

3. The paramount and indisputable authority which, in all our reasonings concerning the human mind, he ascribes to the evidence of consciousness. Of this logical principle he has availed himself, with irresistible force, in refuting the scholastic sophisms against the liberty of human actions, drawn from the prescience of the Deity, and other considerations of a theological nature.

4. The most important, however, of all his improvements in metaphysics, is the distinction which he has so clearly and so strongly drawn between the *primary* and the *secondary* qualities of matter. This distinction was not unknown to some of the ancient schools of philosophy in Greece; but it was afterwards rejected by Aristotle, and by the schoolmen; and it was reserved for Descartes to place it in such a light, as (with the exception of a very few sceptical or rather paradoxical theorists) to unite the opinions of all succeeding inquirers. For this step, so apparently easy, but so momentous in its consequences, Descartes was not indebted to any long or difficult processes of reasoning; but to those habits of accurate and patient attention to the operations of his own mind, which, from his early years, it was the great business of his life to cultivate. It may be proper to add, that the epithets *primary* and *secondary*, now universally employed to mark the distinction in question, were first introduced by Locke; a circumstance

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posing his Treatise of Human Nature. Is it not probable, that he was partly attracted to it, by associations similar to those which presented themselves to the fancy of Cicero, when he visited the walks of the Academy?

In the beginning of Descartes' dissertation upon *Method*, he has given a very interesting account of the pursuits which occupied his youth, and of the considerations which suggested to him the bold undertaking of reforming philosophy.

[1] Such too is the judgment pronounced by D'Alembert. "Les Mathématiques, dont Descartes semble avoir fait assez peu de cas, font neanmoins aujourd'hui la partie la plus solide et la moins contestée de sa gloire." To this he adds a very ingenious reflection on the comparative merits of Descartes, considered as a geometer and as a philosopher. "Comme philosophe, il a peut-être été aussi grand, mais il n'a pas été si heureux. La Géometrie, qui par la nature de son objet doit toujours gagner sans perdre, ne pouvoit manquer, étant maniée par un aussi grand génie de faire des progrès très-sensibles et apparens pour tout le monde. La Philosophie se trouvoit dans un état bien différent, tout y étoit à commencer; *et que ne coûtent point les premiers pas en tout genre! le mérite de les faire dispense de celui d'en faire de grands.*"—*Disc. Prélim.*

[2] "The names of simple ideas are not capable of any definitions; the names of all complex ideas are. It has not, that I know, been yet observed by any body, what words are, and what are not capable of being defined."—(LOCKE's *Essay*, Book iii. chap. iv. § iv.)—Compare this with the *Principia* of Descartes, I. 10.; and with Lord Stair's *Philologia Nova Experimentalis*, pp. 9 and 79, printed at Leyden in 1686.

which may have contributed to throw into the shade the merits of those inquirers who had previously struck into the same path.

As this last article of the Cartesian system has a close connection with several of the most refined conclusions yet formed concerning the intellectual phenomena, I feel it due to the memory of the author, to pause for a few moments, in order to vindicate his claim to some leading ideas, commonly supposed by the present race of metaphysicians to be of much later origin. In doing so, I shall have an opportunity, at the same time, of introducing one or two remarks, which, I trust, will be useful in clearing up the obscurity, which is allowed by some of the ablest followers of Descartes and Locke, still to hang over this curious discussion.

I have elsewhere observed, that Descartes has been very generally charged by the writers of the last century, with a sophistical play upon words in his doctrine concerning the non-existence of secondary qualities; while, in fact, he was the first person by whom the fallacy of this scholastic paralogism was exposed to the world.[1] In proof of this, it might be sufficient to refer to his own statement, in the first part of the *Principia*;[2] but, for a reason which will immediately appear, I think it more advisable, on this occasion, to borrow the words of one of his earliest and ablest commentators. "It is only (says Father Malebranche) since the time of Descartes, that to those confused and indeterminate questions, whether fire is hot, grass green, and sugar sweet, philosophers are in use to reply, by distinguishing the equivocal meaning of the words expressing sensible qualities. If by heat, cold, and savour, you understand such and such a disposition of parts, or some unknown motion of sensible qualities, then fire is hot, grass green, and sugar sweet. But if by heat and other qualities you understand what I feel by fire, what I see in grass, &c. fire is not hot, nor grass green; for the heat I feel, and the colours I see, are only in the soul."[3] It is surprising how this, and other passages to the same purpose in Malebranche, should have escaped the notice of Dr Reid; for nothing more precise on the ambiguity in the names of secondary qualities is to be found in his own works. It is still more surprising that Buffier, who might have been expected to have studied with care the speculations of his illustrious countryman, should have directly charged, not only Descartes, but Malebranche, with maintaining a paradox, which they were at so much pains to banish from the schools of philosophy.[4]

The important observations of Descartes upon this subject, made their way into England very soon after his death. They are illustrated at considerable length, and with great ingenuity, by Glanville, in his *Scepsis Scientifica*, published about thirteen years before Malebranche's *Search after Truth.* So slow, however, is the progress of good sense, when it has to struggle against the prejudices of the learned, that, as lately as 1713, the paradox so clearly explained and refuted by Descartes, appears to have kept some footing in the English universities. In a paper of *the Guardian*, giving an account of a visit paid by Jack Lizard to his mother and sisters, after a year and half's residence at Oxford, the following *précis* is given of his logical attainments. "For the first week (it is said) Jack dealt wholly in paradoxes. It was a common jest with him to pinch one of his sister's lap dogs, and afterwards prove he could not feel it. When the girls were sorting a set of knots, he would demonstrate to them that all the ribbons were of the same colour; or rather, says Jack, of no colour at all. My Lady Lizard herself, though she was not a little pleased with her son's improvements, was one day almost angry with him; for having accidentally burnt her fingers as she was lighting the lamp for her tea-pot, in the midst of her anguish, Jack laid hold of the opportunity to instruct her, that there was no such thing as heat in the fire."

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[1] "Descartes, Malebranche, and Locke, revived the distinction between primary and secondary qualities. But they made the secondary qualities mere sensations, and the primary ones resemblances of our sensations. They maintained that colour, sound, and heat, are not any thing in bodies, but sensations of the mind.——The paradoxes of these philosophers were only an abuse of words. For when they maintain, *as an important modern discovery*, that there is no heat in the fire, they mean no more than that the fire does not feel heat, which every one knew before."—Reid's *Inquiry*, chap. v. sect. viii.

[2] See sections lxix. lxx. lxxi. The whole of these three paragraphs is highly interesting; but I shall only quote two sentences, which are fully sufficient to show, that, in the above observations, I have done Descartes no more than strict justice.

"Patet itaque in re idem esse, cum dicimus nos percipere colores in objectis, ac si diceremus nos percipere aliquid in objectis, quod quidem quid sit ignoramus, sed a quo efficitur in nobis ipsis sensus quidam valde manifestus et perspicuus, qui vocatur sensus colorum.————Cum vero putamus nos percipere colores in objectis, etsi revera nesciamus quidnam sit quod tunc nomine coloris appellamus, nec ullam similitudinem intelligere possimus, inter colorem quem supponimus esse in objectis, et illum quem experimur esse in sensu, quia tamen hoc ipsum non advertimus, et multa alia sunt, ut magnitudo, figura, numerus, &c. quæ clare percipimus not aliter a nobis sentiri vel intelligi, quam ut sunt, aut saltem esse possunt in objectis, facile, in eum errorem delabimur, ut judicemus id, quod in objectis vocamus *colorem*, esse quid omnino simile colori quem sentimus, atque ita ut id quod nullo modo percipimus, a nobis clare percipi arbitraremur."

[3] *Recherche de la Vérité*, Livre vi. chap. ii.

[4] "J'ai admiré souvent que d'aussi grands hommes que Descartes et Malebranche, avec leurs sectateurs, fissent valoir, comme une rare découverte de leur philosophie, que *la chaleur étoit dans nous-mêmes et nullement dans le feu*; au lieu que le commun des hommes trouvoient que *la chaleur étoit dans le feu aussi bien que dans nous.*————Mais en ce fameux débat, de quoi s'agit-il ? Uniquement de l'imperfection du langage, qui causoit une idée confuse par le mot de *chaleur*, ce mot exprimant egalement deux choses, qui à la vérité ont quelque rapport ou analogie, et pourtant qui sont très différentes; savoir, 1. le sentiment de chaleur qui nous éprouvons en nous; 2. la disposition qui est dans le feu à produire en nous ce sentiment de chaleur."—*Cours de Sciences*, par le Père Buffier, p. 819. A Paris, 1732.

This miserable quibble about the non-existence of secondary qualities, never could have attracted the notice of so many profound thinkers, had it not been for a peculiar difficulty connected with our notions of *colour*, of which I do not know any one English philosopher who seems to have been sufficiently aware. That this quality belongs to the same class with sounds, smells, tastes, heat and cold, is equally admitted by the partisans of Descartes and of Locke; and must, indeed, appear an indisputable fact to all who are capable of reflecting accurately on the subject. But still, between *colour* and the other qualities now mentioned, a very important distinction must be allowed to exist. In the case of smells, tastes, sounds, heat and cold, every person must immediately perceive, that his senses give him only *a relative idea* of the external quality; in other words, that they only convey to him the knowledge of the existence of certain properties or powers in external objects, which fit them to produce certain sensations in his mind; and, accordingly, nobody ever hesitated a moment about the truth of this part of the Cartesian philosophy, in so far as *these* qualities alone are concerned. But, in the application of the same doctrine to *colour*, I have conversed with many, with whom I found it quite in vain to argue; and *this*, not from any defect in their reasoning powers, but from their incapacity to reflect steadily on the subjects of their consciousness; or rather, perhaps, from their incapacity to separate, as objects of the understanding, two things indissolubly combined by early and constant habit, as objects of the imagination. The silence of modern metaphysicians on this head is the more surprising, as D'Alembert long ago invited their attention to it as one of the most wonderful phenomena in the history of the human mind. "The bias we acquire," I quote his own words, "in consequence of habits contracted in infancy, to refer to a substance material and divisible, what really belongs to a substance spiritual and simple, is a thing well worthy of the attention of metaphysicians. Nothing," he adds, "is perhaps more extraordinary, in the operations of the mind, than to see it transport its sensations out of itself, and to spread them, as it were, over a substance to which they cannot possibly belong."—It would be difficult to state the fact in question in terms more brief, precise, and perspicuous.

That the illusion, so well described in the above quotation, was not overlooked by Descartes and Malebranche, appears unquestionable, from their extreme solicitude to reconcile it with that implicit faith, which, from religious considerations, they conceived to be due to the testimony of those faculties with which our Maker has endowed us. Malebranche, in particular, is at pains to distinguish between the sensation, and the judgment combined with it. "The sensation never deceives us; it differs in no respect from what we conceive it to be. The *judgment*, too, is natural, or rather (says Malebranche), *it is only a sort of compound sensation*;[1] but this judgment leads us into no error with respect to philosophical truth. The moment we exercise our reason, we see the fact in its true light, and can account completely for that illusive appearance which it presents to the imagination."

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[1] He would have expressed himself more accurately, if he had said, that the judgment is indissolubly combined with the sensation; but his meaning is sufficiently obvious.

Not satisfied, however, with this solution of the difficulty, or rather perhaps apprehensive that it might not appear quite satisfactory to some others, he has called in to his assistance the doctrine of *original sin;* asserting, that all the mistaken judgments which our constitution leads us to form concerning external objects and their qualities, are the consequences of the fall of our first parents; since which *adventure* (as it is somewhat irreverently called by Dr Beattie), it requires the constant vigilance of reason to guard against the numberless tricks and impostures practised upon us by our external senses.[1] In another passage, Malebranche observes very beautifully (though not very consistently with his theological argument on the same point), that our senses being given us for the preservation of our bodies, it was requisite for our well-being, that we should judge as we do of sensible qualities. "In the case of the sensations of *pain* and of *heat*, it was much more advantageous that we should *seem* to feel them in those parts of the body which are immediately affected by them, than that we should associate them with the external objects by which they are occasioned; because pain and heat, having the power to injure our members, it was necessary that we should be warned in what place to apply the remedy; whereas *colours* not being likely, in ordinary cases, to hurt the eye, it would have been superfluous for us to know that they are painted on the *retina.* On the contrary, as they are only useful to us, from the information they convey with respect to things external, it was essential that we should be so formed as to attach them to the corresponding objects on which they depend."[2]

The two following remarks, which I shall state with all possible brevity, appear to me to go far towards a solution of the problem proposed by D'Alembert.

1. According to the *new* theory of vision *commonly* (but, as I shall afterwards show, not altogether *justly*) ascribed to Dr Berkeley, lineal distance from the eye is not an original perception of sight. In the meantime, from the first moment that the eye opens, the most intimate connection must necessarily be established between the notion of *colour* and those of visible extension and figure. At first, it is not improbable that all of them may be conceived to be merely *modifications* of the mind; but, however this may be, the manifest consequence is, that when a comparison between the senses of Sight and of Touch has taught us to refer to a distance the objects of the one, the indissolubly associated sensations of the other must of course accompany them, how far soever that distance may extend.[3]

2. It is well known to be a general law of our constitution, when one thing is destined, either by nature or by convention, to be *the sign* of another, that the mind has a disposition to pass on, as rapidly as possible, to the thing signified, without dwelling on *the sign* as an object worthy of its attention. The most remarkable of all ex-

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[1] "We are informed by Father Malebranche, that the senses were at first as honest faculties as one could desire to be endued with, till after they were debauched by original sin; *an adventure* from which they contracted such an invincible propensity to cheating, that they are now continually lying in wait to deceive us."—*Essay on Truth*, p. 241, second edition.

[2] *Recherche de la Vérité*, Liv. i. chap. xiii. § 5. In Dr Reid's strictures on Descartes and Locke there are two remarks which I am at a loss how to reconcile. "Colour," says he, "differs from other secondary qualities in this, that whereas the name of the quality is sometimes given to the sensation which indicates it, and is occasioned by it, we never, as far as I can judge, give the name of *colour* to the sensation, but to the quality only." A few sentences before, he had observed, "That when we think or speak of any particular colour, however simple the notion may seem to be which is presented to the imagination, it is really in some sort compounded. It involves an unknown cause, and a known effect. The name of *colour* belongs indeed to the cause only, and not to the effect. But as the cause is unknown, we can form no distinct conception of it, but by its relation to the known effect. And, therefore, both go together in the imagination, and are so closely united, that they are mistaken for one simple object of thought."—*Inquiry*, chap. vi. sect. 4.

These two passages seem quite inconsistent with each other. If in the perception of colour, the sensation and the quality "be so closely united as to be mistaken for one single object of thought," does it not obviously follow, that it is to this compounded notion the name of *colour* must, in general, be given? On the other hand, when it is said *that the name of colour is never given to the sensation, but to the quality only*, does not this imply, that every time the word is pronounced, the quality is separated from the sensation, even in the imaginations of the vulgar?

[3] See Note M.

amples of this occurs in the acquired perceptions of sight, where our estimates of distance are frequently the result of an intellectual process, comparing a variety of different *signs* together, without a possibility on our part, the moment afterwards, of recalling one single step of the process to our recollection. Our inattention to the sensations of colour, considered as affections of the Mind, or as modifications of our own being, appears to me to be a fact of precisely the same description; for all these sensations were plainly intended by nature to perform the office of *signs*, indicating to us the figures and distances of things external. Of their essential importance in this point of view, an idea may be formed, by supposing for a moment the whole face of nature to exhibit only one uniform colour, without the slightest variety even of light and shade. Is it not self-evident that, on this supposition, the organ of sight would be entirely useless, inasmuch as it is by the *varieties* of colour alone that the outlines or visible figures of bodies are so defined, as to be distinguishable one from another? Nor could the eye, in this case, give us any information concerning diversities of *distance;* for all the various signs of it, enumerated by optical writers, pre-suppose the antecedent recognition of the bodies around us, as separate objects of perception. It is not therefore surprising, that *signs* so indispensably subservient to the exercise of our noblest sense, should cease, in early infancy, to attract notice as the subjects of our consciousness; and that afterwards they should present themselves to the imagination rather as qualities of Matter, than as attributes of Mind.[1]

To this reference of the sensation of colour to the external object, I can think of nothing so analogous as the feelings we experience in surveying a library of books. We speak of the volumes piled up on its shelves, as *treasures* or *magazines* of the knowledge of past ages; and contemplate them with gratitude and reverence, as inexhaustible *sources* of instruction and delight to the mind. Even in looking at a page of print or of manuscript, we are apt to say, that the ideas we acquire are received by the sense of sight; and we are scarcely conscious of a metaphor, when we employ this language. On such occasions we seldom recollect, that nothing is perceived by the eye but a multitude of *black strokes drawn upon white paper*, and that it is our own acquired habits which communicate to these *strokes* the whole of that significancy whereby they are distinguished from the unmeaning scrawling of an infant or a changeling. The knowledge which we conceive to be preserved in books, like the fragrance of a rose, or the gilding of the clouds, depends, for its existence, on the *relation* between the object and the percipient mind; and the only difference between the two cases is, that in the one, this relation is the local and temporary effect of conventional habits; in the other, it is the universal and the unchangeable work of nature. The art of printing, it is to be hoped, will in future render the former relation, as well as the latter, coeval with our species; but, in the past history of mankind, it is impossible to say how often it may have been dissolved. What vestiges can now be traced of those scientific attainments which, in early times, drew to *Egypt*, from every part of the civilised world, all those who were anxious to be initiated in the mysteries of philosophy? The symbols which still remain in that celebrated country, inscribed on eternal monuments, have long lost the correspondent *minds* which reflected upon them their own intellectual attributes. To us they are useless and silent, and serve only to attest the existence of arts, of which it is impossible to unriddle the nature and the objects.

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[1] In Dr Reid's Inquiry, he has introduced a discussion concerning the perception of *visible figure*, which has puzzled me since the first time (more than forty years ago) that I read his work. The discussion relates to this question, "Whether there be any sensation proper to visible figure, by which it is suggested in vision?" The result of the argument is, that "our eye *might* have been so framed as to suggest the figure of the object, without suggesting colour, or any other quality; and, of consequence, there seems to be *no sensation* appropriated to visible figure; this quality being suggested *immediately* by the material impression upon the organ, of which impression we are not conscious."—*Inquiry*, &c. chap. vi. sect. 8. To my apprehension, nothing can appear more manifest than this, that, if there had been no *variety* in our sensations of colour, and still more, if we had had no sensation of colour whatsoever, the organ of sight could have given us no information, either with respect to *figures* or to *distances;* and, of consequence, would have been as useless to us, as if we had been afflicted, from the moment of our birth, with a *gutta serena*.

> ———— Variis nunc sculpta figuris
> Marmora, trunca tamen visuntur mutaque nobis;
> Signa repertorum tuimur, cecidere reperta.

What has now been remarked with respect to *written characters*, may be extended very nearly to *oral language*. When we listen to the discourse of a public speaker, eloquence and persuasion seem to issue from his lips; and we are little aware, that we ourselves infuse the soul into every word that he utters. The case is exactly the same when we enjoy the conversation of a friend. We ascribe the charm entirely to his voice and accents; but without our cooperation, its potency would vanish. How very small the comparative proportion is, which, in such cases, the words spoken contribute to the intellectual and moral effect, I have elsewhere endeavoured to show.

I have enlarged on this part of the Cartesian system, *not* certainly on account of its intrinsic value, as connected with the theory of our external perceptions (although even in *this* respect of the deepest interest to every philosophical inquirer), but because it affords the most palpable and striking example I know of, to illustrate the indissoluble associations established during the period of infancy between the intellectual and the material worlds. It was plainly the intention of nature, that our thoughts should be habitually directed to things external; and accordingly the bulk of mankind are not only indisposed to study the intellectual phenomena, but are incapable of that degree of reflection which is necessary for their examination. Hence it is, that when we begin to analyse our own internal constitution, we find the facts it presents to us so very intimately combined in our conceptions with the qualities of matter, that it is impossible for us to draw distinctly and steadily the line between them; and that, when Mind and Matter are concerned in the same result, the former is either entirely overlooked, or is regarded only as an accessary principle, dependent for its existence on the latter. To the same cause it is owing, that we find it so difficult (if it be at all practicable) to form an idea of any of our intellectual operations, abstracted from *the images* suggested by their metaphorical names. It was objected to Descartes by some of his contemporaries, that the impossibility of accomplishing the *abstractions* which he recommended, furnished of itself a strong argument against the soundness of his doctrines.[1] The proper answer to this objection does not seem to have occurred to him, nor, so far as I know, to any of his successors;—that the abstractions of the *understanding* are totally different from the abstractions of the *imagination;* and that we may *reason* with most logical correctness about things considered apart, which it is impossible, even in thought, to *conceive* as separated from each other. His own speculations concerning the indissolubility of the union established in the mind between the sensations of colour and the primary qualities of extension and figure, might have furnished him, on this occasion, with a triumphant reply to his adversaries; not to mention that the variety of metaphors, equally fitted to denote the same intellectual powers and operations, might have been urged as a demonstrative proof, that none of these metaphors have any connection with the general laws to which it is the business of the philosopher to trace the mental phenomena.

When Descartes established it as a general principle, that *nothing conceivable by the power of imagination could throw any light on the operations of thought* (a principle which I consider as exclusively his own), he laid the foundation-stone of the Experimental Philosophy of the Human Mind. That the same truth had been previously perceived, more or less distinctly, by Bacon and others, appears probable from the general complexion of their speculations; but which of them has expressed it with equal precision, or laid it down as a fundamental maxim in their logic? It is for this reason, that I am disposed to date the origin of the true Philosophy of Mind from the *Principia* of Descartes rather than from the *Organon* of Bacon, or the *Essay* of Locke; without, however, meaning to compare the French author with our two countrymen, either as a contributor to our stock of *facts* relating to the intellectual phenomena, or as the author of any important conclusion concerning the general laws to which they may be referred. It is mortifying to reflect on the inconceivably small number of subsequent inquirers by whom the spirit of this cardinal maxim has been fully seized; and that, even in our own times, the old and inveterate prejudice to which it is opposed, should not only have been revived with success, but should have been very generally regarded as an original and profound discovery in metaphysical science. These circumstances must plead my apology for the space I have assigned to the Cartesian Metaphysics in the crowded historical picture which I am at present attempting to sketch. The fulness of illustration which I have bestowed on the works of the master, will enable me to pass over those of his disciples, and even of his antagonists, with a correspondent brevity.[1]

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[1] See, in particular, *Gassendi Opera*, Tom. III. pp. 300, 301 Lugduni, 1658.

After having said so much of the singular merits of Descartes as the father of genuine metaphysics, it is incumbent on me to add, that his errors in this science were on a scale of proportionate magnitude. Of these the most prominent (for I must content myself with barely mentioning a few of essential importance) were his obstinate rejection of all speculations about final causes;[2] his hypothesis concerning the lower animals, which he considered as mere machines;[3] his doctrine of *innate* ideas, *as understood and expounded by himself*;[4] his noted paradox of placing the *essence* of mind in thinking, and of matter in extension;[5] and his new modification of the ideal theory of perception, adopted afterwards, with some very slight changes, by Malebranche, Locke, Berkeley, and Hume.[6] To some of these errors I shall have occasion to refer in the sequel of this Discourse. The foregoing slight enumeration is sufficient for my present purpose.

In what I have hitherto said of Descartes, I have taken no notice of his metaphysico-physiological theories relative to the connection between soul and body. Of these theories, however, groundless and puerile as they are, it is necessary for me, before I proceed farther, to say a few words, on account of their extensive and lasting influence on the subsequent history of the science of Mind, not only upon the Continent, but in our own island.

The hypothesis of Descartes, which assigns to the soul for its principal seat the *pineal gland* or *conarion*, is known to every one who has perused the *Alma* of Prior. It is not, perhaps, equally known, that the circumstance which determined him to fix on this particular spot, was the very plausible consideration, that, among the different parts of the brain, *this* was the only one he could find, which, being single and central, was fitted for the habitation of a being, of which he conceived unity and indivisibility to be essential and obvious attributes.[1] In what manner the *animal spirits*, by their motions forwards and backwards in the nervous tubes, keep up the communication between this gland and the different parts of the body, so as to produce the phenomena of perception, memory, imagination, and muscular motion, he has attempted particularly to explain; describing the processes by which these various effects are accomplished, with as decisive a tone of authority, as if he had been demonstrating experimentally the circulation of the blood. How curious to meet with such speculations in the works of the same philosopher, who had so clearly perceived the necessity, in studying the laws of Mind, of abstracting entirely from the analogies of Matter; and who, at the outset of his inquiries, had carried his scepticism so far, as to require a proof even of the existence of his own body! To those, however, who reflect with attention on the *method* adopted by Descartes, this inconsistency will not appear so inexplicable as at first sight may be imagined; inasmuch as the same scepticism which led him to suspend his faith in his intellectual faculties till he had once proved to his satisfaction, from the necessary veracity of God, that these faculties were to be regarded as divine oracles, prepared him, in all the subsequent steps of his progress, to listen to the suggestions of his own fallible judgment, with more than common credulity and confidence.

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[1] The Cartesian doctrine concerning the secondary qualities of matter, is susceptible of various other important applications. Might it not be employed, at least as an *argumentum ad hominem* against Mr Hume and others, who, admitting *this* part of the Cartesian system, seem nevertheless to have a secret leaning to the scheme of materialism? Mr Hume has somewhere spoken of *that little agitation of the brain we call thought*. If it be unphilosophical to confound our *sensations* of colour, of heat, and of cold, with such qualities as extension, figure, and solidity, is it not, if possible, still more so, to confound with these qualities the phenomena of thought, of volition, and of moral emotion?

[2] It is not unworthy of notice, that, in spite of his own logical rules, Descartes sometimes seems insensibly to adopt, on this subject, the common ideas and feelings of mankind. Several instances of this occur in his treatise on the Passions, where he offers various conjectures concerning the *uses* to which they are subservient. The following sentence is more peculiarly remarkable: "Mihi persuadere nequeo, naturam indedisse hominibus ullum affectum qui semper vitiosus sit, nullumque usum bonum et laudabilem habeat."—Art. clxxv.

[3] This hypothesis never gained much ground in England; and yet a late writer of distinguished eminence in *some* branches of science, has plainly intimated that, in his opinion, the balance of probabilities inclined in its favour. "I omit mentioning other animals here," says Mr Kirwan in his *Metaphysical Essays*, "*as it is at least doubtful whether they are not mere automatons.*"—*Met. Essays*, p. 41. Lond. 1809.

[4] I have added the clause in *Italics*, because, in Descartes' reasonings on this question, there is no inconsiderable portion of most important truth, debased by a large and manifest alloy of error.

[5] To this paradox may be traced many of the conclusions of the author, both on physical and on metaphysical subjects. One of the most characteristical features, indeed, of his genius, is the mathematical concatenation of his opinions, even on questions which, at first sight, seem the most remote from each other; a circumstance which, when combined with the extraordinary perspicuity of his style, completely accounts for the strong hold his philosophy took of every mind, thoroughly initiated, at an early period of life, in its principles and doctrines. In consequence of conceiving the essence of matter to consist in extension, he was necessarily obliged to maintain the doctrine of a universal *plenum*; upon which doctrine the theory of the Vortices came to be grafted by a very short and easy process. The same idea forced him, at the very outset of his *Metaphysical Meditations*, to assert, much more dogmatically than his premises seem to warrant, the *non-extension* of Mind; and led him on many occasions to blend, very illogically, this *comparatively* disputable dogma, with the facts he has to state concerning the mental phenomena.

[6] See Note N.

The ideas of Descartes, respecting the communication between soul and body, are now so universally rejected, that I should not have alluded to them here, had it not been for their manifest influence in producing, at the distance of a century, the rival hypothesis of Dr Hartley. The first traces of this hypothesis occur in some *queries* of Sir Isaac Newton, which he was probably induced to propose, less from the conviction of his own mind, than from a wish to turn the attention of philosophers to an examination of the correspondent part of the Cartesian system. Not that I would be understood to deny that this great man seems, on more than one occasion, to have been so far misled by the example of his predecessor, as to indulge himself in speculating on questions altogether unsusceptible of solution. In the present instance, however, there cannot, I apprehend, be a doubt, that it was the application made by Descartes of the old theory of *animal spirits*, to explain the mental phenomena, which led Newton into that train of thinking which served as the groundwork of Hartley's Theory of *Vibrations*.[2]

It would be useless to dwell longer on the reveries of a philosopher, much better known to the learned of the present age by the boldness of his exploded errors, than by the profound and important truths contained in his works. At the period when he appeared, it may perhaps be questioned, whether the truths which he taught, or the errors into which he fell, were most instructive to the world. The controversies provoked by the latter had certainly a more immediate and palpable effect in awakening a general spirit of free inquiry. To this consideration may be added an ingenious and not altogether unsound remark of D'Alembert, that " when absurd opinions are become inveterate, it is sometimes necessary to replace them by other errors, if nothing better can be done. Such (he continues) are the uncertainty and the vanity of the human mind, that it has always need of *an opinion* on which it may lean; it is a child to whom a play-thing must occasionally be presented, in order to get out of its hands a mischievous weapon; the play-thing will soon be abandoned, when the light of reason begins to dawn. [1]

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[1] See in particular, the treatise *De Passionibus*, Art. 31. 32. See also Note O.

[2] The physiological theory of Descartes, concerning the connection between soul and body, was adopted, together with some of his sounder opinions, by a contemporary English philosopher, Mr Smith of Cambridge, whom I had occasion to mention in a former note; and that, for some time after the beginning of the eighteenth century, it continued to afford one of the chief subjects of controversy between the two English universities, the *Alma* of Prior affords incontestable evidence. From the same poem it appears, how much the reveries of Descartes about the *seat of the soul*, contributed to wean *the wits of Cambridge* from their former attachment to the still more incomprehensible pneumatology of the schoolmen.

———————— Here Matthew said,
Alma in verse, in prose the mind
By Aristotle's pen defin'd,
Throughout the body squat or tall,
Is, *bona fide*, all in all,
And yet, slap-dash, is all again
In every sinew, nerve, and vein;
Runs here and there like Hamlet's Ghost,
While everywhere she rules the roast.
 This system, Richard, we are told,
The men of Oxford firmly hold;
The Cambridge wits, you know, deny
With *ipse dixit* to comply.
They say, (for in good truth they speak
With small respect of that old Greek)
That putting all his words together,
'Tis three blue beans in one blue bladder.

Among the opponents of Descartes, Gassendi was one of the earliest, and by far the most formidable. No two philosophers were ever more strongly contrasted, both in point of talents and of temper; the former as far superior to the latter in originality of genius—in powers of concentrated attention to the phenomena of the internal world—in classical taste—in moral sensibility, and in all the rarer gifts of the mind, as he fell short of him in erudition—in industry as a book-maker—in the justness of his logical views, so far as the phenomena of the *material* universe are concerned—and, in general, in those literary qualities and attainments, of which the bulk of mankind either are, or think themselves best qualified to form an estimate. The reputation of Gassendi, accordingly, seems to have been at its height in his own lifetime; that of Descartes made but little progress, till a considerable time after his death.

The comparative justness of Gassendi's views in natural philosophy may be partly, perhaps chiefly, ascribed to his diligent study of Bacon's works; which Descartes (if he ever read them), has nowhere alluded to in his writings. This extraordinary circumstance in the character of Descartes is the more unaccountable, that not only Gassendi, but some of his other correspondents, repeatedly speak of Bacon in terms which one should think could scarcely have failed to induce him to satisfy his own mind whether their encomiums were well or ill founded. One of these, while he contents himself, from very obvious feelings of delicacy, with mentioning the Chancellor of England as the person who, *before the time of Descartes*, had entertained the justest notions about the method of prosecuting physical inquiries, takes occasion, in the same letter, to present him, in the form of a friendly admonition from himself, with the following admirable summary of the *instauratio magna*. " To all this it must be added, that no architect, however skilful, can raise an edifice, unless he be provided with proper materials. In like manner, your *method*, supposing it to be perfect, can never advance you a single step in the explanation of natural causes, unless you are in possession of the facts necessary for determining their effects. They who, without stirring from their libraries, attempt to discourse concerning the works of nature, may indeed tell us what sort of world they would have made, if God had committed that task to their ingenuity; but, without a wisdom truly divine, it is impossible for them to form an idea of the universe, at all approaching to that in the mind of its Creator. And, although your *method* promises everything that can be expected from human

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Alma they strenuously maintain,
Sits cock-horse on her throne the brain,
And from that seat of thought dispenses
Her sovereign pleasure to the senses, &c. &c.

The whole poem, from beginning to end, is one continued piece of ridicule upon the various hypotheses of physiologists concerning the nature of the communication between soul and body. The amusing contrast between the solemn absurdity of these disputes, and the light pleasantry of the excursions to which they lead the fancy of the poet, constitutes the principal charm of this performance; by far the most original and characteristical of all Prior's Works.

[1] See Note P.

genius, it does not, therefore, lay any claim to the art of divination; but only boasts of deducing from the assumed *data*, all the truths which follow from them as legitimate consequences; which *data* can, in physics, be nothing else but principles previously established by experiment."[1] In Gassendi's controversies with Descartes, the name of Bacon seems to be studiously introduced on various occasions, in a manner still better calculated to excite the curiosity of his antagonist; and in his historical review of logical systems, the *heroical attempt which gave birth to the Novum Organon* is made the subject of a separate chapter, immediately preceding that which relates to the *Metaphysical Meditations* of Descartes.

The partiality of Gassendi for the Epicurean physics, if not originally imbibed from Bacon, must have been powerfully encouraged by the favourable terms in which he always mentions the Atomic or Corpuscular theory. In its conformity to that luminous simplicity which everywhere characterises the operations of nature, this theory certainly possesses a decided superiority over all the other conjectures of the ancient philosophers concerning the material universe; and it reflects no small honour on the sagacity both of Bacon and of Gassendi, to have perceived so clearly the strong analogical presumption which this conformity afforded in its favour, prior to the unexpected lustre thrown upon it by the researches of the Newtonian school. With all his admiration, however, of the Epicurean physics, Bacon nowhere shows the slightest leaning towards the metaphysical or ethical doctrines of the same sect; but, on the contrary, considered (and, I apprehend, rightly considered) the atomic theory as incomparably more hostile to atheism, than the hypothesis of four mutable elements, and of one immutable fifth essence. In this last opinion, there is every reason to believe that Gassendi fully concurred; more especially, as he was a zealous advocate for the investigation of *final causes*, even in inquiries strictly physical. At the same time, it cannot be denied, that, on many questions, both of Metaphysics and of Ethics, this very learned theologian (one of the most orthodox, *professedly*, of whom the Catholic church has to boast), carried his veneration for the authority of Epicurus to a degree bordering on weakness and servility; and although, on such occasions, he is at the utmost pains to guard his readers against the dangerous conclusions commonly ascribed to his master, he has nevertheless retained more than enough of his system, to give a plausible colour to a very general suspicion, that he secretly adopted more of it than he chose to avow.

As Gassendi's attachment to the physical doctrines of Epicurus, predisposed him to give an easier reception than he might otherwise have done to his opinions in Metaphysics and in Ethics, so his unqualified contempt for the hypothesis of the Vortices seems to have created in his mind an undue prejudice against the speculations of Descartes on all other subjects. His objections to the argument by which Descartes has so triumphantly established the distinction between Mind and Matter, as separate and heterogeneous objects of human knowledge, must now appear, to every person capable of forming a judgment upon the question, altogether frivolous and puerile; amounting to nothing more than this, that all our knowledge is received by the channel of the external senses,—insomuch, that there is not a single object of the understanding which may not be ultimately analysed into *sensible images;* and, of consequence, that when Descartes proposed to abstract from these images in studying the mind, he rejected the only materials out of which it is possible for our faculties to rear any superstructure. The sum of the whole matter is (to use his own language), that "there is no real distinction between *imagination* and *intellection;* meaning, by the former of these words, the power which the mind possesses of *representing* to itself the material objects and qualities it has previously perceived. It is evident, that this conclusion coincides exactly with the tenets inculcated in England at the same period by his friend Hobbes,[2] as well as with those revived at a later period by Diderot, Horne Tooke, and many other writers, both French and English, who, while they were only repeating the exploded dogmas of Epicurus, fancied they were pursuing, with miraculous success, the new path struck out by the genius of Locke.

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[1] See the first Epistle to Descartes, prefixed to his *Treatise on the Passions*. Amstel. 1664.

[2] The affection of Gassendi for Hobbes, and his esteem for his writings, are mentioned in very strong terms by Sor-

It is worthy of remark, that the argument employed by Gassendi against Descartes, is copied almost *verbatim* from his own version of the account given by *Diogenes Laertius* of the sources of our knowledge, according to the principles of the Epicurean philosophy:[1]—so very little is there of novelty in the consequences deduced by modern materialists from the scholastic proposition, *Nihil est in intellectu quod non fuit prius in sensu.* The same doctrine is very concisely and explicitly stated in a maxim formerly quoted from Montaigne, that "the senses are the *beginning* and *end* of all our knowledge;"—a maxim which Montaigne learned from his oracle Raymond de Sebonde; which, by the present race of French philosophers, is almost universally supposed to be sanctioned by the authority of Locke; and which, if true, would at once cut up by the roots, not only all metaphysics, but all ethics, and all religion, both natural and revealed. It is accordingly with this very maxim that Madame du Deffand (in a letter which rivals anything that the fancy of Molière has conceived in his *Femmes Savantes*) assails Voltaire for his imbecility in attempting a reply to an atheistical book then recently published. In justice to this celebrated lady, I shall transcribe part of it in her own words, as a precious and authentic document of the philosophical tone affected by the higher orders in France, during the reign of Louis XV.

"J'entends parler d'une réfutation d'un certain livre *(Système de la Nature)*. Je voudrois l'avoir. Je m'en tiens à connoitre ce livre par vous. Toutes réfutations de système doivent être bonnes, surtout quand c'est vous qui les faites. Mais, mon cher Voltaire, ne vous ennuyez-vous pas de tous les raisonnemens métaphysiques sur les matières inintelligibles. *Peut-on donner des idées, ou peut-on en admettre d'autres que celles que nous reçevons par nos sens?*"—If the Senses be *the beginning* and *end* of all our knowledge, the inference here pointed at is quite irresistible.[2]

A learned and profound writer has lately complained of the injustice done by the present age to Gassendi; in whose works, he asserts, may be found the whole of the doctrine commonly ascribed to Locke concerning the origin of our knowledge.[3] The remark is certainly just, if restricted to Locke's doctrine as interpreted by the greater part of philosophers on the Continent; but it is very wide of the truth, if applied to it as now explained and modified by the most intelligent of his disciples in this country. The main scope, indeed, of Gassendi's argument against Descartes, is to materialise that class of our ideas which the Lockists as well as the Cartesians consider as the exclusive objects of the power of *reflection;* and to show that these ideas are all ultimately resolvable into images or conceptions borrowed from things external. It is not, therefore, what is sound and valuable in this part of Locke's system, but the errors grafted on it in the comments of some of his followers, that can justly be said to have been borrowed from Gassendi. Nor has Gassendi the merit of originality, even in these errors; for scarcely a remark on the subject occurs in his works, but what is copied from the accounts

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bière. "Thomas Hobbius Gassendo charissimus, cujus libellum *De Corpore* paucis ante obitum mensibus accipiens, osculatus est, subjungens, *mole quidem parvus est iste liber, verum totus, ut opinor, medulla scatet!*"—(SORBERII *Pref.*) Gassendi's admiration of Hobbes' Treatise *De Cive*, was equally warm; as we learn from a letter of his to Sorbière, prefixed to that work.

[1] Compare GASSENDI *Opera*, Tom. III. p. 300, 301; and Tom. V. p. 12.

[2] Notwithstanding the evidence (according to *my* judgment) of this conclusion, I trust it will not be supposed that I impute the slightest bias in its favour to the generality of those who have adopted the premises. If an author is to be held chargeable with all the consequences logically deducible from his opinions, who can hope to escape censure? And, in the present instance, how few are there among Montaigne's disciples, who have ever reflected for a moment on the real meaning and import of the proverbial maxim in question!

[3] Gassendi fut le prémier auteur de la nouvelle philosophie de l'esprit humain; car il est tems de lui rendre, à cet égard, une justice qu'il n'a presque jamais obtenue de ses propres compatriotes. Il est très singulier en effet, qu'en parlant de la nouvelle philosophie de l'esprit humain, nous disions toujours, *la philosophie de Locke.* D'Alembert et Condillac ont autorisé cette expression, en rapportant l'un et l'autre à Locke exclusivement la gloire de cette invention, &c. &c.—DEGERANDO, *Hist. Comp. des Systèmes*, Tome I. p. 301.

transmitted to us of the Epicurean metaphysics.

Unfortunately for Descartes, while he so clearly perceived that the origin of those ideas which are the most interesting to human happiness, could not be traced to our external senses, he had the weakness, instead of stating this fundamental proposition in plain and precise terms, to attempt an explanation of it by the extravagant hypothesis of *innate ideas*. This hypothesis gave Gassendi great advantages over him, in the management of their controversy; while the subsequent adoption of Gassendi's reasonings against it by Locke, has led to a very general but ill-founded belief, that the latter, as well as the former, rejected, along with the doctrine of *innate ideas*, the various important and well-ascertained truths combined with it in the Cartesian system.[1]

The hypothetical language afterwards introduced by Leibnitz concerning the human soul (which he sometimes calls a *living mirror of the universe*, and sometimes supposes to contain within itself *the seeds* of that knowledge which is gradually unfolded in the progressive exercise of its faculties), is another impotent attempt to explain a mystery unfathomable by human reason. The same remark may be extended to some of Plato's reveries on this question, more particularly to his supposition, that those ideas which cannot be traced to any of our external senses, were acquired by the soul in its state of pre-existence. In all of these theories, as well as in that of Descartes, the cardinal truth is assumed as indisputable, that the Senses *are not* the only sources of human knowledge; nor is any thing wanting to render them correctly logical, but the statement of this truth as an ultimate fact (or at least as a fact hitherto unexplained) in our intellectual frame.

It is very justly observed by Mr Hume, with respect to Sir Isaac Newton, that "while he seemed to draw off the veil from some of the mysteries of nature, he showed, at the same time, the imperfections of the mechanical philosophy, and thereby restored her ultimate secrets to that obscurity in which they ever did, and ever will remain."[2] When the justness of this remark shall be as universally acknowledged in the science of Mind as it now is in Natural Philosophy, we may reasonably expect that an end will be put to those idle controversies which have so long diverted the attention of metaphysicians from the proper objects of their studies.

The text of Scripture, prefixed by Dr Reid as a motto to his *Inquiry*, conveys, in a few words, the result of his own modest and truly philosophical speculations on the origin of our knowledge, and expresses this result in terms strictly analogous to those in which Newton speaks of the law of gravitation :—"*The inspiration of the Almighty hath given them understanding.*" Let our researches concerning the developement of Mind, and the *occasions* on which its various notions are first formed, be carried back ever so far towards the commencement of its history, in *this* humble confession of human ignorance they must terminate at last.

I have dwelt thus long on the writings of Gassendi, much less from my own idea of their merits, than out of respect to an author, in whose footsteps Locke has frequently condescended to tread. The epigrammatic encomium bestowed on him by Gibbon, who calls him, "le meilleur philosophe des littérateurs, et le meilleur littérateur des philosophes," appears to me quite extravagant.[3] His learning, indeed, was at once vast and accurate; and, as a philosopher he is justly entitled to the praise of being one of the first who entered thoroughly into the spirit of the Baconian logic. But his inventive powers, which were probably not of the highest order, seem to have been either dissipated amidst the multiplicity of his literary pursuits, or laid asleep by his indefatigable labours as a commentator and a compiler. From a writer of this class, new lights were not to be expected in the study of the human Mind; and accordingly, *here* he has done little or nothing, but to revive and to repeat over the doctrines of the old Epicureans. His works amount to six large volumes in folio; but the substance of them might be compressed into a much smaller compass, without any diminution of their value.

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[1] See Note Q.

[2] *History of Great Britain*, chap. lxxi.

[3] *Essai sur l'Etude de la Littérature.*

In *one* respect Gassendi had certainly a great advantage over his antagonist,—the good humour which never forsook him in the heat of a philosophical argument. The comparative indifference with which he regarded most of the points at issue between them, was perhaps the chief cause of that command of temper so uniformly displayed in all his controversies, and so remarkably contrasted with the constitutional irritability of Descartes. Even the faith of Gassendi in his own favourite master, Epicurus, does not seem to have been very strong or dogmatical, if it be true that he was accustomed to allege, as the chief ground of his preferring the Epicurean physics to the theory of the Vortices, "that chimera for chimera, he could not help feeling some partiality for that which was two thousand years older than the other."[1]

About twenty years after the death of Gassendi (who did not long survive Descartes), Malebranche entered upon his philosophical career. The earlier part of his life had, by the advice of some of his preceptors, been devoted to the study of ecclesiastical history, and of the learned languages; for neither of which pursuits does he seem to have felt that marked predilection which afforded any promise of future eminence. At length, in the twenty-fifth year of his age, he accidentally met with Descartes' *Treatise on Man*, which opened to him at once a new world, and awakened him to a consciousness of powers, till then unsuspected either by himself or by others. Fontenelle has given a lively picture of the enthusiastic ardour with which Malebranche first read this performance; and describes its effects on his nervous system as sometimes so great, that he was forced to lay aside the book till the palpitation of his heart had subsided.

It was only ten years after this occurrence when he published *The Search after Truth;* a work which, whatever judgment may now be passed on its philosophical merits, will always form an interesting study to readers of taste, and a useful one to students of human nature. Few books can be mentioned, combining, in so great a degree, the utmost depth and abstraction of thought, with the most pleasing sallies of imagination and eloquence; and none, where they who delight in the observation of intellectual character may find more ample illustrations, both of the strength and weakness of the human understanding. It is a singular feature in the history of Malebranche, that, notwithstanding the poetical colouring which adds so much animation and grace to his style, he never could read, without disgust, a page of the finest verses;[2] and that, although Imagination was manifestly the predominant ingredient in the composition of his own genius, the most elaborate passages in his works are those where he inveighs against this treacherous faculty, as the prolific parent of our most fatal delusions.[3]

In addition to the errors, more or less incident to all men, from the unresisted sway of imagination during the infancy of reason, Malebranche had, in his own case, to struggle with all the prejudices connected with the peculiar dogmas of the Roman Catholic faith. Unfortunately, too, he everywhere discovers a strong disposition to blend his theology and his metaphysics together; availing himself of the one as an auxiliary to the other, wherever in either science his ingenuity fails him in establishing a favourite conclusion. To this cause is chiefly to be ascribed the little attention now paid to a writer formerly so universally admired, and, in point of fact, the indisputable author of some of the most refined speculations claimed by the theorists of the eighteenth century. As for those mystical controversies about *Grace* with Anthony Arnauld, on which he wasted so much of his genius, they have long sunk into utter oblivion; nor should I have here revived the recollection of them, were it not for the authentic record they furnish of the passive bondage in which, little more than a hundred years ago, two of the most powerful minds of that memorable period were held by a creed, renounced at the Reformation by all the Protestant countries of Europe, and the fruitful source, wherever it has been retained, of other prejudices, not less to be lamented, of an opposite description.[1]

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[1] See Note R.

[2] Bayle—Fontenelle—D'Alembert.

[3] In one of his arguments on this head, Malebranche refers to the remarks previously made on the same subject by an English philosopher, who, like himself, has more than once taken occasion, while warning his readers against the undue influence of imagination over the judgment, to exemplify the boundless fertility and originality of his own. The following allusion of Bacon's, quoted by Malebranche, is eminently apposite and happy:—"Omnes perceptiones tam sensus quam mentis sunt ex analogia hominis, non ex analogia universi: Estque intellectus humanus instar speculi inæqualis ad radios rerum, qui suam naturam naturæ rerum immiscet, eamque distorquet et inficit.

When Malebranche touches on questions not positively decided by the church, he exhibits a remarkable boldness and freedom of inquiry; setting at nought those human authorities which have so much weight with men of unenlightened erudition; and sturdily opposing his own reason to the most inveterate prejudices of his age. His disbelief in the reality of sorcery, which, although cautiously expressed, seems to have been complete, affords a decisive proof of the soundness of his judgment, where he conceived himself to have any latitude in exercising it. The following sentences contain more good sense on the subject, than I recollect in any contemporary author. I shall quote them, as well as the other passages I may afterwards extract from his writings, in his own words, to which it is seldom possible to do justice in an English version.

"Les hommes même les plus sages se conduisent plutôt par l'imagination des autres, je veux dire par l'opinion et par la coûtume, que par les regles de la raison. Ainsi dans les lieux où l'on brule les sorciers, on ne voit autre chose, parce que dans les lieux où l'on les condamne au feu, on croit veritablement qu'ils le sont, et cette croyance se fortifie par les discours qu'on en tient. Que l'on cesse de les punir, et qu'on les traite comme des fous, et l'on verra qu'avec le tems ils ne seront plus sorciers; parce que ceux qui ne le sont que par imagination, qui font certainement le plus grand nombre, deviendront comme les autres hommes.

"C'est donc avec raison que plusieurs Parlemens ne punissent point les sorciers: ils s'en trouve beaucoup moins dans les terres de leur ressort: Et l'envie, et la malice des méchans ne peuvent se servir de ce prétexte pour accabler les innocens."

How strikingly has the sagacity of these anticipations and reflections been verified, by the subsequent history of this popular superstition in our own country, and indeed in every other instance where the experiment recommended by Malebranche has been tried! Of this sagacity much must, no doubt, be ascribed to the native vigour of a mind struggling against and controlling early prejudices; but it must not be forgotten, that, notwithstanding his retired and monastic life, Malebranche had breathed the same air with the associates and friends of Descartes and of Gassendi; and that no philosopher seems ever to have been more deeply impressed with the truth of that golden maxim of Montaigne—"Il est bon de frotter et limer notre cervelle contre celle d'autrui."

Another feature in the intellectual character of Malebranche, presenting an unexpected contrast to his powers of abstract meditation, is the attentive and discriminating eye with which he appears to have surveyed the habits and manners of the comparatively little circle around him; and the delicate yet expressive touches with which he has marked and defined some of the nicest shades and varieties of genius.[2] To this branch of the Philosophy of Mind, not certainly the least important and interesting, he has contributed a greater number of original remarks than Locke himself;[1] since whose time, with the single exception of Helvetius, hardly any attention has been paid to it, either by French or English metaphysicians. The same practical knowledge of the human understanding, modified and diversified, as we everywhere see it, by education and external circumstances, is occasionally discovered by his very able antagonist Arnauld; affording, in both cases, a satisfactory proof, that the narrowest field of experience may disclose to a superior mind those refined and comprehensive results, which common observers are forced to collect from an extensive and varied commerce with the world.

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[1] Of this disposition to blend theological dogmas with philosophical discussions, Malebranche was so little conscious in himself, that he seriously warned his readers against it, by quoting an aphorism of Bacon's, peculiarly applicable to his own writings:—Ex divinorum et humanorum malesana admixtione non solum educitur philosophia phantastica, sed etiam religio hæretica. Itaque salutare admodum est si mente sobria fidei tantum dentur quæ fidei sunt." In transcribing these words, it is amusing to observe, that Malebranche has slily suppressed the name of the author from whom they are borrowed; manifestly from an unwillingness to weaken their effect, by the suspicious authority of a philosopher not in communion with the Church of Rome.—*Recherche de la Vérité*, Liv. ii. chap. ix.

Dr Reid, proceeding on the supposition that Malebranche was a Jesuit, has ascribed to the antipathy between this order and the Jansenists, the warmth displayed on both sides, in his disputes with Arnauld (*Essays on the Intell. Powers*, p. 124.): but the fact is, that Malebranche belonged to the Congregation of the *Oratory;* a society much more nearly allied to the Jansenists than to the Jesuits; and honourably distinguished, since its first origin, by the moderation as well as learning of its members.

[2] See, among other passages, *Recherche de la Vérité*, Liv. ii. chap. ix

In some of Malebranche's incidental strictures on men and manners, there is a lightness of style and fineness of *tact*, which one would scarcely have expected from the mystical divine, who believed that *he saw all things in God.* Who would suppose that the following paragraph forms part of a profound argument on the influence of the external senses over the human intellect?

" Si, par exemple, celui qui parle s'énonce avec facilité, s'il garde une mesure agréable dans ses périodes, s'il a l'air d'un honnête homme et d'un homme d'esprit, si c'est une personne de qualité, s'il est suivi d'un grand train, s'il parle avec autorité et avec gravité, si les autres l'écoutent avec respect et in silence, s'il a quelque réputation, et quelque commerce avec les esprits du premier ordre, enfin, s'il est assez heureux pour plaire, ou pour être estimé, il aura raison dans tout ce qu'il avancera; et il n'y aura pas jusqu'à son collet et à ses manchettes, qui ne prouvent quelque chose."[2]

In his philosophical capacity, Malebranche is to be considered in two points of view: 1. As a commentator on Descartes; and, 2. As the author of some conclusions from the Cartesian principles, not perceived or not avowed by his predecessors of the same school.

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[1] In one of Locke's most noted remarks of this sort, he has been anticipated by Malebranche, on whose clear yet concise statement he does not seem to have thrown much new light by his very diffuse and wordy commentary. " If in having our ideas in the memory ready at hand, consists quickness of parts; in this of having them unconfused, and being able nicely to distinguish one thing from another, where there is but the least difference, consists, in a great measure, the exactness of judgment and clearness of reason, which is to be observed in one man above another. And hence, perhaps, may be given some reason of that common observation, that men who have a great deal of wit, and prompt memories, have not always the clearest judgment, or deepest reason. For Wit, lying most in the assemblage of ideas, and putting those together with quickness and variety, *wherein* can be found any resemblance or congruity, *thereby* to make up pleasant pictures, and agreeable visions in the fancy; Judgment, on the contrary, lies quite on the other side, in separating carefully, one from another, ideas *wherein* can be found the least difference, *thereby* to avoid being misled by similitude, and by affinity to take one thing for another."—*Essay, &c.* B. ii. c. xi. § 2.

" Il y a donc des esprits de deux sortes. Les uns remarquent aisément les différences des choses, et ce sont les bons esprits. Les autres imaginent et supposent de la ressemblance entr'elles, et ce sont les esprits superficiels."—*Rech. de la Vérité*, Liv. ii. *Seconde Partie*, chap. ix.

At a still earlier period, Bacon had pointed out the same cardinal distinction in the intellectual characters of individuals.

" Maximum et velut radicale discrimen ingeniorum, quoad philosophiam et scientias, illud est; quod alia ingenia sint fortiora et aptiora ad notandas rerum differentias; alia, ad notandas rerum similitudines. Ingenia enim constantia et acuta, figere contemplationes, et morari, et hærere in omni subtilitate differentiarum possunt. Ingenia autem sublimia, et discursiva, etiam tenuissimas et catholicas rerum similitudines et cognoscunt, et componunt. Utrumque autem ingenium facile labitur in excessum, prensando aut gradus rerum, aut umbras."

That strain I heard was of a higher mood! It is evident, that Bacon has here seized, in its most general form, the very important truth perceived by his two ingenious successors in particular cases. *Wit*, which Locke contrasts with *judgment*, is only one of the various talents connected with what Bacon calls the *discursive genius;* and indeed, a talent very subordinate in dignity to most of the others.

[2] I shall indulge myself only in one other citation from Malebranche, which I select partly on account of the curious extract it contains from an English publication long since forgotten in this country; and partly as a proof that this learned and pious father was not altogether insensible to the ludicrous.

" Un illustre entre les Sçavans, qui a fondé des chaires de Géometrie et d'Astronomie dans l'Université d'Oxford,[*] commence un livre, qu'il s'est avisé de faire sur les huit premières propositions d'Euclide, par ces paroles: *Consilium meum est, auditores, si vires et valetudo suffecerint, explicare definitiones, petitiones, communes sententias, et octo priores propositiones primi libri Elementorum, cætera post me venientibus relinquere:* et il le finit par celles-ci: *Exsolvi per Dei gratiam, Domini auditores, promissum, liberavi fidem meam, explicavi pro modulo meo definitiones, petitiones, communes sententias, et octo priores propositiones Elementorum Euclidis. Hic annis fessus cyclos artemque repono. Succedent in hoc munus alii fortasse magis vegeto corpore et vivido ingenio.* Il ne faut pas une heure à un esprit mediocre, pour apprendre par lui-même, ou par le secours du plus petit géometrie qu'il y ait, les definitions, demandes, axiomes, et les huit premières propositions d'Euclide: et voici un auteur qui parle de cette entreprise, comme de quelque chose de fort grand et de fort difficile. Il a peur que les forces lui manquent: *Si vires et valetudo suffecerint.* Il laisse à ses successeurs à pousser ces choses: *cætera post me venientibus relinquere.* Il remercie Dieu de ce que, par une grace particulière, il a executé ce qu'il avoit promis: *exsolvi per Dei gratiam promissum, liberavi fidem meam, explicavi pro modulo meo.* Quoi? la quadrature du cercle? la duplication du cube? Ce grande homme a expliqué *pro modulo suo*, les definitions, les demandes, les axiomes, et les huit premières propositions du premier livre des *Elemens*

[*] Sir Henry Savile. The work here referred to is a 4to volume, entitled, *Prelectiones xiii. in Principium Elementorum Euclidis, Oxoniæ habitæ*, anno 1620.

1. I have already taken notice of Malebranche's comments on the Cartesian doctrine concerning the *sensible*, or, as they are now more commonly called, *the secondary qualities* of matter. The same fulness and happiness of illustration are everywhere else to be found in his elucidations of his master's system; to the popularity of which he certainly contributed greatly by the liveliness of his fancy, and the charms of his composition. Even in *this* part of his writings, he always preserves the air of an original thinker; and, while pursuing the same path with Descartes, seems rather to have accidentally struck into it from his own casual choice, than to have selected it out of any deference for the judgment of another. Perhaps it may be doubted, if it is not on such occasions that the inventive powers of his genius, by being somewhat restrained and guided in their aim, are most vigorously and most usefully displayed.

In confirmation of this last remark, I shall only mention, by way of examples, his comments on the Cartesian theory of Vision,—more especially on that part of it which relates to our experimental estimates of the distances and magnitudes of objects; and his admirable illustration of the errors to which we are liable from the illusions of sense, of imagination, and of the passions. In his physiological reveries on the union of soul and body, he wanders, like his master, in the dark, from the total want of facts as a foundation for his reasonings; but even here his genius has had no inconsiderable influence on the inquiries of later writers. The fundamental principle of Hartley is most explicitly stated in *The Search after Truth*;[1] as well as a hypothesis concerning the nature of *habits*, which, rash and unwarranted as it must now appear to every novice in science, was not thought unworthy of adoption in *The Essay on Human Understanding*.[2]

2. Among the opinions which chiefly characterise the system of Malebranche, the leading one is, that the *causes* which it is the aim of philosophy to investigate are only *occasional causes;* and that the Deity is himself the *efficient* and *immediate cause* of every effect in the

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d'Euclide. Peut-être qu'entre ceux qui lui succederont, il s'en trouvera qui auront plus de santé, et plus de force que lui pour continuer ce bel ouvrage: *Succedent in hoc munus alii* FORTASSE *magis vegeto corpore et vivido ingenio.* Mais pour lui il est tems qu'il se repose; *hic annis fessus cyclos artemque repono.*"

After reading the above passage, it is impossible to avoid reflecting, with satisfaction, on the effect which the progress of philosophy has since had, in removing those obstacles to the acquisition of useful knowledge, which were created by the pedantic taste prevalent two centuries ago. What a contrast to a quarto commentary on the definitions, postulates, axioms, and first eight propositions of Euclid's First Book, is presented by Condorcet's estimate of the time now sufficient to conduct a student to the highest branches of Mathematics! "Dans le siècle dernier, il suffisoit de quelques années d'étude pour savoir tout ce qu'Archimede et Hipparque avoient pu connoître; et aujourd'hui deux années de l'enseignement d'un professeur vont au dela de ce que savoient Leibnitz ou Newton."—*(Sur l'Instruction Publique.)* In this particular science, I am aware that much is to be ascribed to the subsequent invention of new and more general *methods;* but, I apprehend, not a little also to the improvements gradually suggested by experience, in what Bacon calls the *traditive* part of logic.

[1] "Toutes nos différentes perceptions sont attachées aux différens changemens qui arrivent dans les fibres de la partie principale du cerveau dans laquelle l'âme réside plus particulièrement."—*(Rech. de la Vérité*, Liv. ii. chap. v.) These *changes* in the fibres of the brain are commonly called by Malebranche *ébranlemens;*—a word which is frequently rendered by his old English translator (Taylor) *vibrations.* "La seconde chose," says Malebranche, "qui se trouve dans chacune des sensations, est *l'ébranlement* des fibres de nos nerfs, qui se communique jusqu'au cerveau:" thus translated by Taylor: "The second thing that occurs in every sensation is the *vibration* of the fibres of our nerves, which is communicated to the brain."—Liv. i. chap. xii.) Nor was the theory of *association* overlooked by Malebranche. See, in particular, the third chapter of his second book, entitled, *De la liaison mutuelle des idées de l'esprit, et des traces du cerveau; et de la liaison mutuelle des traces avec les traces, et des idées avec les idées.*

[2] "Mais afin de suivre nôtre explication, il faut remarquer que les esprits ne trouvent pas toujours les chemins, par où ils doivent passer assez ouverts et assez libres: et que cela fait qui nous avons de la difficulté à remuer, par exemple, les doigts avec la vitesse qui est nécessaire pour jouer des instrumens de musique, ou les muscles qui servent à la prononciation, pour prononcer les mots d'une langue étrangere: Mais que peu-a-peu *les esprits animaux par leur cours continuel ouvrent et applanissent ces chemins*, en sorte qu'avec le tems ils n'y trouvent plus de resistance. Car c'est dans cette facilité que les esprits animaux ont de passer dans les membres de nôtre corps que consistent les habitudes."—*Rech. de la Vérité*, Liv. ii. chap. v.

"Habits seem to be but trains of motion in the animal spirits, which, once set a-going, continue in the same steps they have been used to, *which, by often treading, are worn into a smooth path.*"—LOCKE, Book ii. chap. xxxiii. §. 6.

universe.[1] From this single principle, the greater part of his distinguishing doctrines may be easily deduced, as obvious corollaries.

That we are completely ignorant of the manner in which *physical causes* and *effects* are connected, and that all our knowledge concerning them amounts merely to a perception of *constant conjunction*, had been before remarked by Hobbes, and more fully shown by Glanville in his *Scepsis Scientifica.* Malebranche, however, has treated the same argument much more profoundly and ably than any of his predecessors, and has, indeed, anticipated Hume in some of the most ingenious reasonings contained in his Essay on *Necessary Connexion.* From these *data*, it was not unnatural for his pious mind to conclude, that what are commonly called *second causes* have no existence; and that the Divine power, incessantly and universally exerted, is, in truth, the connecting link of all the phenomena of nature. It is obvious that, in this conclusion, he went farther than his premises warranted; for, although no necessary connections among physical events can be traced by our faculties, it does not therefore follow that such connections are impossible. The only sound inference was, that the laws of nature are to be discovered, *not*, as the ancients supposed, by *a priori* reasonings from causes to effects, but by experience and observation. It is but justice to Malebranche to own, that he was one of the first who placed in a just and strong light this fundamental principle of the inductive logic.

On the other hand, the objections to the theory of *occasional causes*, chiefly insisted on by Malebranche's opponents, were far from satisfactory. By some it was alleged, that it ascribed every event to a miraculous interposition of the Deity; as if this objection were not directly met by the general and constant *laws* everywhere manifested to our senses,—in a departure from which laws, the very essence of a *miracle* consists. Nor was it more to the purpose to contend, that the beauty and perfection of the universe were degraded by excluding the idea of *mechanism;* the whole of this argument turning, as is manifest, upon an application to Omnipotence of ideas borrowed from the limited sphere of human power.[2] As to the study of natural philosophy, it is plainly not at all affected by the hypothesis in question; as the investigation and generalisation of the laws of nature, which are its only proper objects, present exactly the same field to our curiosity, whether we suppose these *laws* to be the immediate effects of the Divine agency, or the effects of *second causes*, placed beyond the reach of our faculties.[3]

Such, however, were the chief reasonings opposed to Malebranche by Leibnitz, in order to prepare the way for the system of *Pre-established Harmony;* a system more nearly allied to that of *occasional causes* than its author seems to have suspected, and encumbered with every solid difficulty connected with the other.

From the theory of *occasional causes*, it is easy to trace the process which led Malebranche to conclude, *that we see all things in God.* The same arguments which convinced him, that the Deity carries into execution every *volition* of the mind, in the movements of the body, could not fail to suggest, as a farther consequence, that every *perception* of the mind is the immediate effect of the divine illumination. As to the *manner* in which this illumination is accomplished, the extraordinary hypothesis adopted by Malebranche was forced upon him, by the opinion then universally held, that the immediate objects of our perceptions are not things external, but their *ideas* or images. The only possible expedient for reconciling these two articles of his creed, was to transfer the seat of our *ideas* from our own minds to that of the Creator.[1]

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[1] " Afin qu'on ne puisse plus douter de la fausseté de cette misérable philosophie, il est nécessaire de prouver qu'il n'y a qu'un vrai Dieu, parce qu'il n'y a qu'une vraie cause; que la nature ou la force de chaque chose n'est que la volonté de Dieu: que toutes les causes naturelles ne sont point des véritables causes, mais seulement des causes occasionelles.—*De la Vérité*, Livre vi. 2de Partie, chap. iii.

[2] This objection, frivolous as it is, was strongly urged by Mr Boyle *(Inquiry into the Vulgar Idea concerning Nature)*, and has been copied from him by Mr Hume, Lord Kaimes, and many other writers. Mr Hume's words are these:—" It argues more wisdom to contrive at first the fabric of the world with such perfect foresight, that, of itself, and by its proper operation, it may serve all the purposes of Providence, than if the great Creator were obliged every moment to adjust its parts, and animate by his breath all the wheels of that stupendous machine."—*Essay on the Idea of Necessary Connection.)* An observation somewhat similar occurs in the Treatise *De Mundo*, commonly ascribed to Aristotle.

[3] In speaking of the theory of *occasional causes*, Mr Hume has committed a historical mistake, which it may be proper to rectify. " Malebranche," he observes, and other Cartesians, made the doctrine of the universal and sole efficacy of the Deity, the foundation of all their philosophy. *It had, however, no authority in England.* Locke, Clarke, and Cudworth, never so much as take notice of it, but suppose all along that matter has a real, though subordinate and derived power."—*Hume's Essays*, Vol. II. p. 475. Edit. of 1784.

Mr Hume was probably led to connect, in this last sentence, the name of Clarke with those of Locke and Cudworth, by taking for granted that his metaphysical opinions agreed exactly with those commonly ascribed to Sir Isaac Newton. In fact, on the point now in question, his creed was the same with that of Malebranche. The following sentence is very nearly a translation of a passage already quoted from the latter. " The course of nature, truly and properly speaking, is nothing but the will of God producing certain effects in a continued, regular, constant, and uniform manner."—CLARKE'S *Works* Vol. II. p. 698. Fol. Ed.

In this theory of Malebranche, there is undoubtedly, as Bayle has remarked,[2] an approach to some speculations of the latter Platonists; but there is a much closer coincidence between it and the system of those Hindoo philosophers, who, according to Sir William Jones, "believed that the whole creation was rather an *energy* than a *work;* by which the Infinite Mind, who is present at all times, and in all places, exhibits to his creatures a set of perceptions, like a wonderful picture, or piece of music, always varied, yet always uniform."[3]

In some of Malebranche's reasonings upon this subject, he has struck into the same train of thought which was afterwards pursued by Berkeley, an author to whom he bore a very strong resemblance in some of the most characteristical features of his genius; and, had he not been restrained by religious scruples, he would, in all probability, have asserted, not less confidently than his successor, that the existence of matter was demonstrably inconsistent with the principles then universally admitted by philosophers. But this conclusion Malebranche rejects, as not reconcileable with the words of Scripture, that "in the beginning God created the heavens and the earth." "La foi m'apprend que Dieu a créé le ciel et la terre. Elle m'apprend que l'Ecriture est un livre divin. Et ce livre ou son apparence me dit nettement et positivement, qu'il y a mille et mille creatures. Donc voilà toutes mes apparences changées en realités. Il y a des corps; cela est démontré en toute rigueur la foy supposée."[4]

In reflecting on the repeated reproduction of these, and other ancient paradoxes, by modern authors, whom it would be highly unjust to accuse of plagiarism;—still more, in reflecting on the affinity of some of our most refined theories to the popular belief in a remote quarter of the globe, one is almost tempted to suppose, that human invention is limited, like a barrel-organ, to a specific number of tunes. But is it not a fairer inference, that the province of pure Imagination, unbounded as it may at first appear, is narrow, when compared with the regions opened by truth and nature to our powers of observation and reasoning?[5] Prior to the time of Bacon, the physical systems of the learned performed their periodical revolutions in orbits as small as the metaphysical hypotheses of their successors; and yet, who would now set any bounds to our curiosity in the study of the material universe? Is it reasonable to think, that the phenomena of the intellectual world are less various, or less marked with the signatures of Divine wisdom?

It forms an interesting circumstance in the history of the two memorable persons who have suggested these remarks, that they had *once,* and only *once*, the pleasure of a short interview. "The conversation," we are told, "turned on the non-existence of matter. Malebranche, who had an inflammation in his lungs, and whom Berkeley found preparing a medicine in his cell, and cooking it in a small pipkin, exerted his voice so violently in the heat of their dispute, that he increased his disorder, which carried him off a few days after."[1] It is impossible not to regret, that of this interview there is no other record;—or rather, that Berkeley had not made it the groundwork of one of his own dialogues. Fine as his imagination was, it could scarcely have added to the picturesque effect of the real scene.[2]

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[1] We are indebted to La Harpe for the preservation of an epigrammatic line *(un vers fort plaisant,* as he justly calls it), on this celebrated hypothesis: "*Lui, qui voit tout en Dieu, n'y voit-il pas qu'il est fou!*—C'étoit au moins," La Harpe adds, "un fou qui avoit beaucoup d'esprit."

[2] See his Dictionary, article *Âmelius.*

[3] Introduction to a Translation of some Hindoo verses.

[4] *Entretiens sur la Métaphysique,* p. 207.

The celebrated *doubt* of Descartes concerning all truths but the existence of his own *mind* (it cannot be too often repeated), was the real source, not only of the inconsistency of Malebranche on this head, but of the chief metaphysical *puzzles* afterwards started by Berkeley and Hume. The illogical transition by which he attempted to pass from this first principle to other truths, was early remarked by some of his own followers, who were accordingly led to conclude, that no man can have full assurance of any thing but of his own individual existence. If the fundamental doubt of Descartes be admitted as reasonable, the conclusion of these philosophers (who were distinguished by the name of *Egoists),* is unavoidable.

[5] The limited number of fables, of humorous tales, and even of jests, which, it should seem, are in circulation over the face of the globe, might perhaps be alleged as an additional confirmation of this idea.

Anthony Arnauld, whom I have already mentioned as one of the theological antagonists of Malebranche, is also entitled to a distinguished rank among the French philosophers of this period. In his book *on true and false ideas*, written in opposition to Malebranche's scheme of our seeing all things in God, he is acknowledged by Dr Reid to have struck the first mortal blow at the *ideal theory;* and to have approximated very nearly to his own refutation of this ancient and inveterate prejudice.[3] A step so important would, of itself, be sufficient to establish his claim to a place in literary history; but what chiefly induces me again to bring forward his name, is the reputation he has so justly acquired by his treatise, entitled, *The Art of Thinking;*[4] a treatise written by Arnauld, in conjunction with his friend Nicole, and of which (considering the time when it appeared) it is hardly possible to estimate the merits too highly. No publication, certainly, prior to Locke's *Essay*, can be named, containing so much good sense, and so little nonsense on the science of Logic; and very few have *since* appeared on the same subject, which can be justly preferred to it, in point of practical utility. If the author had lived in the present age, or had been less fettered by a prudent regard to existing prejudices, the technical part would probably have been reduced within a still narrower compass; but even there, he has contrived to substitute for the puerile and contemptible examples of common logicians, several interesting illustrations from the physical discoveries of his immediate predecessors; and has indulged himself in some short excursions, which excite a lively regret that he had not, more frequently and freely, given scope to his original reflections. Among these excursions, the most valuable, in my opinion, is the twentieth chapter of the third part, which deserves the attention of every logical student, as an important and instructive supplement to the enumeration of sophisms given by Aristotle.[1]

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[1] *Biog. Brit.* Vol. II. p. 251.

[2] This interview happened in 1715, when Berkeley was in the thirty-first, and Malebranche in the seventy-seventh year of his age. What a change in the state of the philosophical world (whether for the better or worse is a different question) has taken place in the course of the intervening century!

Dr Warburton, who, even when he thinks the most unsoundly, always possesses the rare merit of thinking for himself, is one of the very few English authors who have spoken of Malebranche with the respect due to his extraordinary talents. "All you say of Malebranche," he observes in a letter to Dr Hurd, "is strictly true; he is an admirable writer. There is something very different in the fortune of Malebranche and Locke. When Malebranche first appeared, it was with a general applause and admiration; when Locke first published his *Essay*, he had hardly a single approver. Now Locke is universal, and Malebranche sunk into obscurity. All this may be easily accounted for. The intrinsic merit of either was out of the question. But Malebranche supported his first appearance on a philosophy in the highest vogue; that philosophy has been overturned by the Newtonian, and Malebranche has fallen with his master. It was to no purpose to tell the world, that Malebranche could stand without him. The public never examines so narrowly. Not but that there was another cause sufficient to do the business; and that is, his debasing his noble work with his system of seeing all things in God. When this happens to a great author, one half of his readers out of folly, the other out of malice, dwell only on the unsound part, and forget the other, or use all their arts to have it forgotten.

"But the sage Locke supported himself by no system on the one hand; nor, on the other, did he dishonour himself by any whimsies. The consequence of which was, that, neither following the fashion, nor striking the imagination, he, at first, had neither followers nor admirers; but being everywhere clear, and everywhere solid, he at length worked his way, and afterwards was subject to no reverses. He was not affected by the new fashions in philosophy, who leaned upon none of the old; nor did he afford ground for the after-attacks of envy and folly by any fanciful hypotheses, which, when grown stale. are the most nauseous of all things."

The foregoing reflections on the opposite fates of these two philosophers, do honour on the whole to Warburton's penetration; but the unqualified panegyric on Locke will be now very generally allowed to furnish an additional example of "that national spirit, which," according to Hume, "forms the great happiness of the English, and leads them to bestow on all their eminent writers such praises and acclamations, as may often appear partial and excessive."

[3] The following very concise and accurate summary of Arnauld's doctrine concerning *ideas*, is given by Brucker. "Antonius Arnaldus, ut argumenta Malebranchii eo fortius everteret, peculiarem sententiam defendit, asseruitque, ideas earumque perceptiones esse unum idemque, et non nisi relationibus differre. Ideam scilicet esse, quatenus ad objectum refertur quod mens considerat; perceptionem vero, quatenus ad ipsam mentem quæ percipit; duplicem tamen illam relationem ad unam pertinere mentis modificationem."—*Hist. Phil. de Ideis*, pp. 247. 248. Anthony Arnauld farther held, that "Material things are perceived *immediately* by the mind, without the intervention of *ideas*."—(*Hist. de Ideis*, p. 26.) In this respect his doctrine coincided exactly with that of Reid.

[4] More commonly known by the name of the *Port-Royal Logic*.

The soundness of judgment, so eminently displayed in the *Art of Thinking*, forms a curious contrast to that passion for theological controversy, and that zeal for what he conceived to be the purity of the Faith, which seems to have been the ruling passions of the author's mind. He lived to the age of eighty-three, continuing to write against Malebranche's opinions concerning *Nature and Grace*, to his last hour. "He died," says his biographer, "in an obscure retreat at Brussels, in 1692, without fortune, and even without the comfort of a servant; *he*, whose nephew had been a Minister of State, and who might himself have been a Cardinal. The pleasure of being able to *publish* his sentiments, was to him a sufficient recompense." Nicole, his friend and companion in arms, worn out at length with these incessant disputes, expressed a wish to retire from the field, and to enjoy repose. "*Repose!*" replied Arnauld; "won't you have the whole of eternity to repose in?"

An anecdote which is told of his infancy, when considered in connection with his subsequent life, affords a good illustration of the force of impressions received in the first dawn of reason. He was amusing himself one day with some childish sport, in the library of the Cardinal du Perron, when he requested of the Cardinal to give him a pen:—"And for what purpose?" said the Cardinal.—"To write books, like you, against the Huguenots." The Cardinal, it is added, who was then old and infirm, could not conceal his joy at the prospect of so hopeful a successor; and, as he was putting the pen into his hand, said, "I give it to *you*, as the dying shepherd Damœtas bequeathed his pipe to the little Corydon."

The name of Pascal (*that prodigy of parts*, as Locke calls him) is more familiar to modern ears than that of any of the other learned and polished anchorites, who have rendered the sanctuary of *Port-Royal* so illustrious; but his writings furnish few materials for philosophical history. Abstracting from his great merits in mathematics and in physics, his reputation rests chiefly on the *Provincial Letters;* a work from which Voltaire, notwithstanding his strong prejudices against the author, dates the *fixation* of the French language; and of which the same excellent judge has said, that "Molière's best comedies do not excel them in wit, nor the compositions of Bossuet in sublimity." The enthusiastic admiration of Gibbon for this book, which he was accustomed from his youth to read once a year, is well known, and is sufficient to account for the rapture with which it never fails to be spoken of by *the erudite vulgar*[2] in this country. I cannot help, however, suspecting, that it is now more praised than read in Great Britain; so completely have those disputes, to which it owed its first celebrity, lost their interest. Many passages in it, indeed, will always be perused with delight; but it may be questioned, if Gibbon himself would have read it so often from beginning to end, had it not been for the strong hold which ecclesiastical controversies, and the Roman Catholic faith, had early taken of his mind.

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[1] According to Crousaz, *The Art of Thinking* contributed more than either the *Organon* of Bacon, or the *Method* of Descartes, to improve the established modes of academical education on the Continent.—(See the Preface to his *Logic*, printed at Geneva, 1724.) Leibnitz himself has mentioned it in the most flattering terms; coupling the name of the author with that of Pascal, a still more illustrious ornament of the *Port-Royal* Society:—"Ingeniosissimus Pascalius in præclara dissertatione de ingenio Geometrico, cujus fragmentum extat in egregio libro celeberrimi viri Antonii Arnaldi de Arte bene Cogitandi," &c.; but lest this encomium from so high an authority should excite a curiosity somewhat out of proportion to the real value of the two works here mentioned, I think it right to add, that the praises bestowed by Leibnitz, whether on living or dead authors, are not always to be strictly and literally interpreted. "No one," says Hume, "is so liable to an excess of admiration as a truly great genius." Wherever Leibnitz has occasion to refer to any work of solid merit, this remark applies to him with peculiar force; partly, it is probable, from his quick and sympathetic perception of congenial excellence, and partly from a generous anxiety to point it out to the notice of the world. It affords, on the other hand, a remarkable illustration of the force of prejudice, that Buffier, a learned and most able Jesuit, should have been so far influenced by the hatred of his order to the Jansenists, as to distinguish the *Port-Royal Logic* with the cold approbation of being "a judicious *compilation* from former works on the same subject,—particularly from a treatise by a Spanish Jesuit, *Fonséca*."—*Cours de Sciences*, p. 873. Paris, 1732. Gibbon also has remarked how much "the learned Society of Port-Royal contributed to establish in France a taste for just reasoning, simplicity of style, and philosophical method."—*Misc. Works*, Vol. II. p. 70.

[2] *Eruditum Vulgus.*—PLIN. *Nat. Hist.* Lib. ii.

In one respect, the *Provincial Letters* are well entitled to the attention of philosophers; inasmuch as they present so faithful and lively a picture of the influence of false religious views in perverting the moral sentiments of mankind. The overwhelming ridicule lavished by Pascal on the whole system of jesuitical casuistry, and the happy effects of his pleasantry in preparing, from a distance, the fall of that formidable order, might be quoted as proofs, that there are at least *some* truths, in whose defence this weapon may be safely employed;—perhaps with *more* advantage than the commanding voice of Reason herself. The mischievous absurdities which it was his aim to correct, scarcely admitted of the gravity of logical discussion; requiring only the extirpation or the prevention of those early prejudices which choke the growth of common sense and of conscience: And for this purpose, what so likely to succeed with the open and generous minds of youth, as Ridicule, managed with decency and taste; more especially when seconded, as in the *Provincial Letters*, by acuteness of argument, and by the powerful eloquence of the heart? In this point of view, few practical moralists can boast of having rendered a more important service than Pascal to the general interests of humanity. Were it not, indeed, for his exquisite satire, we should already be tempted to doubt, if, at so recent a date, it were possible for such extravagances to have maintained a dangerous ascendant over the human understanding.

The unconnected fragment of Pascal, entitled *Thoughts on Religion*, contains various reflections which are equally just and ingenious; some which are truly sublime; and not a few which are false and puerile: the whole, however, deeply tinctured with that ascetic and morbid melancholy, which seems to have at last produced a partial eclipse of his faculties. Voltaire has animadverted on this fragment with much levity and petulance; mingling, at the same time, with many very exceptionable strictures, several of which it is impossible to dispute the justness. The following reflection is worthy of Addison, and bears a strong resemblance in its spirit to the amiable lessons inculcated in his papers on Cheerfulness;[1] "To consider the world as a dungeon, and the whole human race as so many criminals doomed to execution, is the idea of an enthusiast; to suppose the world to be a seat of delight, where we are to expect nothing but pleasure, is the dream of a Sybarite; but to conclude that the Earth, Man, and the lower Animals, are, all of them, subservient to the purposes of an unerring Providence, is, in my opinion, the system of a wise and good man."

From the sad history of this great and excellent person (on whose deep superstitious gloom it is the more painful to dwell, that, by an unaccountable, though not singular coincidence, it was occasionally brightened by the inoffensive play of a lively and sportive fancy) the eye turns with pleasure to repose on the *mitis sapientia*, and the Elysian imagination of Fenelon. The interval between the deaths of these two writers is indeed considerable; but that between their births does not amount to thirty years; and, in point of education, both enjoyed nearly the same advantages.

The reputation of Fenelon as a philosopher would probably have been higher and more universal than it is, if he had not added to the depth, comprehension, and soundness of his judgment, so rich a variety of those more pleasing and attractive qualities, which are commonly regarded rather as the flowers than the fruits of study. The same remark may be extended to the Fenelon of England, whose ingenious and original essays on the *Pleasures of Imagination* would have been much more valued by modern metaphysicians, had they been less beautifully and happily written. The characteristical excellence, however, of the Archbishop of Cambray is, that *moral wisdom*, which (as Shaftesbury has well observed), " comes more from the heart than from the head ;" and which seems to depend less on the reach of our reasoning powers, than on the absence of those narrow and malignant passions, which, on all questions of ethics and polities (perhaps I might add of religion also), are the chief source of our speculative errors.

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[1] *Spectator*, No. 381 and 387.

The *Adventures of Telemachus*, when considered as a production of the seventeenth century, and still more as the work of a Roman Catholic Bishop, is a sort of prodigy ; and it may, to this day, be confidently recommended, as the best manual extant, for impressing on the minds of youth the leading truths, both of practical morals and of political economy. Nor ought it to be concluded, because these truths appear to lie so near the surface, and command so immediately the cordial assent of the understanding, that they are therefore obvious or trite ; for the case is the same with *all* the truths most essential to human happiness. The importance of agriculture and of religious toleration to the prosperity of states ; the criminal impolicy of thwarting the kind arrangements of Providence, by restraints upon commerce ; and the duty of legislators to study the laws of the moral world as the groundwork and standard of their own, appear, to minds unsophisticated by inveterate prejudices, as approaching nearly to the class of axioms ;—yet, how much ingenious and refined discussion has been employed, even in our own times, to combat the prejudices which everywhere continue to struggle against them ; and how remote does the period yet seem, when there is any probability that these prejudices shall be completely abandoned !

" But how," said Telemachus to Narbal, " can such a commerce as this of Tyre be established at Ithaca ?" " By the same means," said Narbal, " that have established it here. Receive all strangers with readiness and hospitality ; let them find convenience and liberty in your ports ; and be careful never to disgust them by avarice or pride : above all, never restrain the freedom of commerce, by rendering it subservient to your own immediate gain. The pecuniary advantages of commerce should be left wholly to those by whose labour it subsists ; lest this labour, for want of a sufficient motive, should cease. There are more than equivalent advantages of another kind, which must necessarily result to the Prince from the wealth which a free commerce will bring into his state ; and commerce is a kind of spring, which to divert from its natural channel is to lose."[1] Had the same question been put to Smith or to Franklin in the present age, what sounder advice could they have offered ?

In one of Fenelon's *Dialogues of the Dead*, the following remarkable words are put into the mouth of Socrates : " It is necessary that a people should have written laws, always the same, and consecrated by the whole nation ; that these laws should be paramount to every thing else ; that those who govern should derive their authority from *them* alone ; possessing an unbounded power to do all the good which the laws prescribe, and restrained from every act of injustice which the laws prohibit."

But it is chiefly in a work which did not appear till many years after his death, that we have an opportunity of tracing the enlargement of Fenelon's political views, and the extent of his Christian charity. It is entitled, *Direction pour la Conscience d'un Roi ;* and abounds with as liberal and enlightened maxims of government as, under the freest constitutions, have ever been offered by a subject to a sovereign. Where the variety of excellence renders selection so difficult, I must not venture upon any extracts ; nor, indeed, would I willingly injure the effect of the whole by quoting detached passages. A few sentences on *liberty of conscience* (which I will not presume to translate) may suffice to convey an idea of the general spirit with which it is animated. " Sur toute chose, ne forcez jamais vos sujets à changer de religion.

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[1] HAWKESWORTH's Translation.

Nulle puissance humaine ne peut forcer le retranchement impénétrable de la liberté du cœur. La force ne peut jamais persuader les hommes; elle ne fait que des hypocrites. Quand les rois se mêlent de religion, au lieu de la protéger, ils la mettent en servitude. Accordez à tous la tolerance civile, non en approuvant tout comme indifférent, mais en souffrant avec patience tout ce que Dieu souffre, et en tâchant de ramener les hommes par une douce persuasion."

And so much for the French philosophy of the seventeenth century. The extracts last quoted forewarn us, that we are fast approaching to a new era in the history of the Human Mind. *The glow-worm 'gins to pale his ineffectual fire;* and we *scent the morning air* of the coming day. This era I propose to date from the publications of Locke and of Leibnitz: but the remarks which I have to offer on their writings, and on those of their most distinguished successors, I reserve for the Second Part of this Discourse, confining myself, at present, to a very short retrospect of the state of philosophy, during the preceding period, in some other countries of Europe.[1]

SECTION III.

Progress of Philosophy during the Seventeenth Century, in some parts of Europe, not included in the preceding Review.

During the first half of the seventeenth century, the philosophical spirit which had arisen with such happy auspices in England and in France, has left behind it few or no traces of its existence in the rest of Europe. On all questions connected with the *science of mind* (a phrase which I here use in its largest acceptation), authority continued to be everywhere mistaken for argument; nor can a single work be named, bearing, in its character, the most distant resemblance to the *Organon* of Bacon; to the *Meditations* of Descartes; or to the bold theories of that sublime genius, who, soon after, was to shed so dazzling a lustre on the north of Germany. Kepler and Galileo still lived;—the former languishing in poverty at Prague; the latter oppressed with blindness, and with ecclesiastical persecution, at Florence: but their pursuits were of a nature altogether foreign to our present subject.

One celebrated work alone, the treatise of Grotius *De Jure Belli et Pacis* (first printed in 1625), arrests our attention among the crowd of useless and forgotten volumes, which were then issuing from the presses of Holland, Germany, and Italy. The influence of this treatise, in giving a new direction to the studies of the learned, was so remarkable, and continued so long to operate with undiminished effect, that it is necessary to allot to the author, and to his successors, a space considerably larger than may, at first sight, seem due to their merits. Notwithstanding the just neglect into which they have lately fallen in our universities, it will be found, on a close examination, that they form an important link in the history of modern literature. It was from their school that most of our best writers on Ethics have proceeded, and many of our most original inquirers into the Human Mind; and it is to the same school (as

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[1] I have classed *Télémaque* and the *Direction pour la Conscience d'un Roi* with the philosophy of the seventeenth century, although the publication of the former was not permitted till after the death of Louis XIV. nor that of the latter till 1748. The tardy appearance of both only shows how far the author had shot a-head of the orthodox religion and politics of his times.

I shall endeavour to show in the Second Part of this Discourse), that we are chiefly indebted for the modern science of Political Economy.[1]

For the information of those who have not read the treatise *De Jure Belli et Pacis*, it may be proper to observe, that, under this title, Grotius has aimed at a complete system of Natural Law. Condillac says, that he chose the title, in order to excite a more general curiosity; adding (and, I believe, very justly), that many of the most prominent defects of his works may be fairly ascribed to a compliance with the taste of his age. "The author," says Condillac, "was able to think for himself; but he constantly labours to support his conclusions by the authority of others; producing, on many occasions, in support of the most obvious and indisputable propositions, a long string of quotations from the Mosaic law; from the Gospels; from the Fathers of the Church; from the Casuists; and, not unfrequently, in the very same paragraph, from Ovid and Aristophanes." In consequence of this cloud of witnesses, always at hand to attest the truth of his axioms, not only is the attention perpetually interrupted and distracted; but the author's reasonings, even when perfectly solid and satisfactory, fail in making a due impression on the reader's mind; while the very little that there probably was of systematical arrangement in the general plan of the book, is totally kept out of view.

In spite of these defects, or rather, perhaps, in consequence of some of them, the impression produced by the treatise in question, on its first publication, was singularly great. The stores of erudition displayed in it recommended it to the classical scholar; while the happy application of the author's reading to the affairs of human life, drew the attention of such men as Gustavus Adolphus; of his Prime Minister, the Chancellor Oxenstiern; and of the Elector Palatine, Charles Lewis. The last of these was so struck with it, that he founded at Heidelberg a Professorship for the express purpose of teaching the Law of Nature and Nations;—an office which he bestowed on Puffendorff, the most noted, and, on the whole, the most eminent of those who have aspired to tread in the footsteps of Grotius.

The fundamental principles of Puffendorff possess little merit in point of originality, being a sort of medley of the doctrines of Grotius, with some opinions of Hobbes; but his book is entitled to the praise of comparative conciseness, order, and perspicuity; and accordingly came very generally to supplant the treatise of Grotius, as a manual or institute for students, notwithstanding its immense inferiority in genius, in learning, and in classical composition.

The authors who, in different parts of the Continent, have since employed themselves in commenting on Grotius and Puffendorff; or in abridging their systems; or in altering their arrangements, are innumerable: but notwithstanding all their industry and learning, it would be very difficult to name any class of writers whose labours have been of less utility to the world. The same ideas are constantly recurring in an eternal circle; the opinions of Grotius and of Puffendorff, where they are at all equivocal, are anxiously investigated, and sometimes involved in additional obscurity; while, in the meantime, the science of Natural Jurisprudence never advances one single step; but, notwithstanding its recent birth, seems already sunk into a state of dotage.[2]

In perusing the systems now referred to, it is impossible not to feel a very painful dissatisfaction, from the difficulty of ascertaining the precise object aimed at by the authors. So vague and indeterminate is the general scope of their researches, that not only are different views of the subject taken by different writers, but even by the same writer in different parts of his work;—a circumstance which, of itself, sufficiently accounts for the slender additions they have made to the stock of useful knowledge; and which is the real source of that chaos of heterogeneous discussions, through which the reader is perpetually forced to fight his way. A distinct conception of these different views will be found to throw more light than might at first be expected on the subsequent history of Moral and of Political Science; and I shall therefore endeavour, as accurately as I can, to disentangle and separate them from each other, at the risk perhaps of incurring, from some readers, the charge of prolixity. The most important of them may, I apprehend, be referred to one or other of the following heads:

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[1] From a letter of Grotius, quoted by Gassendi, we learn, that the treatise *De Jure Belli et Pacis* was undertaken at the request of his learned friend Peireskius. "Non otior, sed in illo de jure gentium opere pergo, quod si tale futurum est, ut lectores demereri possit, habebit quod tibi debeat posteritas, qui me ad hunc laborem et auxilio et hortatu tuo excitasti."—Gassendi *Opera*, Tom. V. p. 294.

[2] I have borrowed, in this last paragraph, some expressions from Lampredi. "Grotii et Puffendorfii interpretes, viri quidem diligentissimi, sed qui vix fructum aliquem tot commentariis, adnotationibus, compendiis, tabulis, cæterisque ejusmodi aridissimis laboribus attulerunt: perpetuo circulo eadem res circumagitur, quid uterque senserit quæritur, interdum etiam utriusque sententiæ obscurantur; disciplina nostra tamen ne latum quidem unguem progreditur, et dum aliorum sententiæ disquiruntur et explanantur, Rerum Natura quasi senio confecta squalescit, neglectaque jacet et inobservata omnino.—(*Juris Publici Theoremata*, p. 34.)

1. Among the different ideas which have been formed of Natural Jurisprudence, one of the most common (particularly in the earlier systems) supposes its object to be—to lay down those rules of justice which *would* be binding on men living in a social state, without any positive institutions; or (as it is frequently called by writers on this subject), living together in a *state of nature.* This idea of the province of Jurisprudence seems to have been uppermost in the mind of Grotius, in various parts of his treatise.

To this speculation about the state of nature, Grotius was manifestly led by his laudable anxiety to counteract the attempts then recently made to undermine the foundations of morality. That moral distinctions are created entirely by the arbitrary and revealed will of God, had, before his time, been zealously maintained by some theologians even of the reformed church; while, among the political theorists of the same period, it was not unusual to refer these distinctions (as was afterwards done by Hobbes) to the positive institutions of the civil magistrate. In opposition to both, it was contended by Grotius, that there is a natural law coeval with the human constitution, from which positive institutions derive all their force; a truth which, how obvious and trite soever it may now appear, was so opposite in its spirit to the illiberal systems taught in the monkish establishments, that he thought it necessary to exhaust in its support all his stores of ancient learning. The older writers on Jurisprudence must, I think, be allowed to have had great merit in dwelling so much on this fundamental principle; a principle which renders "*Man a Law to himself;*" and which, if it be once admitted, reduces the metaphysical question concerning the nature of the moral faculty, to an object merely of speculative curiosity.[1] To this faculty the ancients frequently give the name of *reason;* as in that noted passage of Cicero, where he observes, that "right reason is itself *a law;* congenial to the feelings of nature; diffused among all men; uniform; eternal; calling us imperiously to our duty, and peremptorily prohibiting every violation of it. Nor does it speak," continues the same author, "one language at Rome and another at Athens, varying from place to place, or time to time; but it addresses itself to all nations and to all ages; deriving its authority from the common sovereign of the universe, and carrying home its sanctions to every breast, by the inevitable punishment which it inflicts on transgressors."[2]

The habit of considering morality under the similitude of *a law* (*a law* engraved on the human heart), led not unnaturally to an application to ethical subjects of the technical language and arrangements of the Roman jurisprudence, and this innovation was at once facilitated and encouraged, by certain peculiarities in the nature of the most important of all the virtues,—that of justice; peculiarities which, although first explained fully by Hume and Smith, were too prominent to escape altogether the notice of preceding moralists.

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[1] "Upon whatever we suppose that our moral faculties are founded, whether upon a certain modification of reason, upon an original instinct, called a moral sense, or upon some other principle of our nature, it cannot be doubted that they were given us for the direction of our conduct in this life. They carry along with them the most evident badges of this authority, which denote that they were set up within us to be the supreme arbiters of all our actions, to superintend all our senses, passions, and appetites, and to judge how far each of them was either to be indulged or restrained. The rules, therefore, which they prescribe, are to be regarded as the commands and *laws of the Deity*, promulgated by those vicegerents which he has set up within us."—SMITH's *Theory of Moral Sentiments*, Part iii. chap. v.)—See also Dr BUTLER's very original and philosophical *Discourses on Human Nature.*

[2] *Frag.* Lib. iii. *de Rep.*

The circumstances which distinguish justice from the other virtues, are chiefly two. In the first place, its rules may be laid down with a degree of accuracy, whereof moral precepts do not, in any other instance, admit. Secondly, its rules may be enforced, inasmuch as every transgression of them implies a violation of the rights of others. For the illustration of both propositions, I must refer to the eminent authors just mentioned.

As, in the case of justice, there is always a right, on the one hand, corresponding to an obligation on the other, the various rules enjoined by it may be stated in two different forms; either as a system of duties, or as a system of rights. The former view of the subject belongs properly to the moralist—the latter to the lawyer. It is this last view that the writers on Natural Jurisprudence (most of whom were lawyers by profession) have in general chosen to adopt; although, in the same works, both views will be found to be not unfrequently blended together.

To some indistinct conception among the earlier writers on Natural Law, of these peculiarities in the nature of justice, we may probably ascribe the remarkable contrast pointed out by Mr Smith, between the ethical systems of ancient and of modern times. "In none of the ancient moralists," he observes, "do we find any attempt towards a particular enumeration of the rules of justice. On the contrary, Cicero in his Offices, and Aristotle in his Ethics, treat of justice in the same general manner in which they treat of generosity or of charity."[1]

But although the rules of justice are in every case precise and indispensable; and although their authority is altogether independent of that of the civil magistrate, it would obviously be absurd to spend much time in speculating about the principles of this natural law, as applicable to men, before the establishment of government. The same state of society which diversifies the condition of individuals to so great a degree as to suggest problematical questions with respect to their rights and their duties, necessarily gives birth to certain conventional laws or customs, by which the conduct of the different members of the association is to be guided; and agreeably to which the disputes that may arise among them are to be adjusted. The imaginary state referred to under the title of the *State of Nature*, though it certainly does not exclude the idea of *a moral right of property arising from labour*, yet excludes all that variety of cases concerning its alienation and transmission, and the mutual covenants of parties, which the political union alone could create;—an order of things, indeed, which is virtually supposed in almost all the speculations about which the law of nature is commonly employed.

2. It was probably in consequence of the very narrow field of study which Jurisprudence, considered in this light, was found to open, that its province was gradually enlarged, so as to comprehend, not merely the rules of justice, but the rules enjoining all our other moral duties. Nor was it only the *province* of Jurisprudence which was thus enlarged. A corresponding extension was also given, by the help of arbitrary definitions, to its *technical phraseology*, till at length the whole doctrines of practical ethics came to be moulded into an artificial form, originally copied from the Roman code. Although justice is the only branch of virtue in which every moral Obligation implies a corresponding Right, the writers on Natural Law have contrived, by fictions of *imperfect rights*, and of *external rights*, to treat indirectly of all our various duties, by pointing out the rights which are supposed to be their correlates:—in other words, they have contrived to exhibit, in the form of a system of rights, a connected view of the whole duty of man. This idea of Jurisprudence, which identifies its object with that of Moral Philosophy, seems to coincide nearly with that of Puffendorff; and some vague notion of the same sort

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[1] *Theory of Moral Sentiments*, Part vii. sect. iv.

has manifestly given birth to many of the digressions of Grotius.

Whatever judgment may now be pronounced on the effects of this innovation, it is certain that they were considered, not only at the time, but for many years afterwards, as highly favourable. A very learned and respectable writer, Mr Carmichael of Glasgow, compares them to the improvements made in Natural Philosophy by the followers of Lord Bacon. “No person,” he observes, “liberally educated, can be ignorant, that, within the recollection of ourselves and of our fathers, philosophy has advanced to a state of progressive improvement hitherto unexampled; in consequence partly of the rejection of scholastic absurdities, and partly of the accession of new discoveries. Nor does this remark apply solely to Natural Philosophy, in which the improvements accomplished by the united labours of the learned have forced themselves on the notice even of the vulgar, by their palpable influence on the mechanical arts. The other branches of philosophy also have been prosecuted during the last century with no less success; and none of them in a more remarkable degree than the science of Morals.

“This science, so much esteemed, and so assiduously cultivated by the sages of antiquity, lay, for a length of time, in common with all the other useful arts, buried in the rubbish of the dark ages, till (soon after the commencement of the seventeenth century), the incomparable treatise of *Grotius de Jure Belli et Pacis* restored to more than its ancient splendour that part of it which defines the relative duties of individuals; and which, in consequence of the immense variety of cases comprehended under it, is by far the most extensive of any. Since that period, the most learned and polite scholars of Europe, as if suddenly roused by the alarm of a trumpet, have vied with each other in the prosecution of this study,—so strongly recommended to their attention, not merely by its novelty, but by the importance of its conclusions, and the dignity of its object.”[1]

I have selected this passage, in preference to many others that might be quoted to the same purpose from writers of higher name; because, in the sequel of this historical sketch, it appears to me peculiarly interesting to mark the progress of Ethical and Political speculation in that seat of learning, which, not many years afterwards, was to give birth to the *Theory of Moral Sentiments*, and to the *Inquiry into the Nature and Causes of the Wealth of Nations*. The powerful effect which the last of these works has produced on the political opinions of the whole civilised world, renders it unnecessary, in a Discourse destined to form part of a Scotish *Encyclopedia*, to offer any apology for attempting to trace, with some minuteness, the train of thought by which an undertaking, so highly honourable to the literary character of our country, seems to have been suggested to the author.

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[1] The last sentence is thus expressed in the original. “Ex illo tempore, quasi classico dato, ab eruditissimis passim et politissimis viris excoli certatim cœpit, utilissima hæc nobilissimaque doctrina.”—See the edition of Puffendorff, *De Officio Hominis et Civis*, by Professor Gerschom Carmichael of Glasgow, 1724; an author whom Dr Hutchison pronounces to be “by far the best commentator on Puffendorff; and “whose *notes*,” he adds, “are of much more value than the *text*.”—See his short *Introduction to Moral Philosophy*.

Puffendorff's principal work, entitled *De Jure Naturæ et Gentium*, was first printed in 1672, and was afterwards abridged by the author into the small volume referred to in the foregoing paragraph. The idea of Puffendorff's aim, formed by Mr Carmichael, coincides exactly with the account of it given in the text: “Hoc demum tractatu edito, facile intellexerunt æquiores harum rerum arbitri, non aliam esse genuinam *Morum Philosophiam*, quam quæ ex evidentibus principiis, in ipsa rerum natura fundatis, hominis atque civis officia, in singulis vitæ humanæ circumstantiis debita, eruit ac demonstrat; atque adeo Juris Naturalis scientiam, quantumvis diversam ab Ethica quæ in scholis dudum obtinuerat, præ se ferret faciem, non esse, quod ad scopum et rem tractandam, vere aliam disciplinam, sed eandem rectius duntaxat et solidius traditam, ita ut, ad quam prius male collineaverit, tandem reipsa feriret scopum.”—See Carmichael's edition of the treatise *De Officio Hominis et Civis*, p. 7.

To so late a period did this admiration of the treatise *De Officio Hominis et Civis*, continue in our Scotch Universities, that the very learned and respectable Sir John Pringle (afterwards President of the Royal Society of London), adopted it as the text-book for his lectures, while he held the Professorship of Moral Philosophy at Edinburgh. Nor does the case seem to have been different in England. “I am going,” says Gray, in a letter written while a student at Cambridge, “to attend a lecture on *one* Puffendorff.” And, much in the same spirit, Voltaire thus expresses himself with respect to the schools of the Continent:—“On est partagé, dans les écoles, entre Grotius et Puffendorff. Croyez-moi, lisez les Offices de Ciceron.” From the contemptuous tone of these two writers, it should seem that the old systems of Natural Jurisprudence had entirely lost their credit among men of taste and of enlarged views, long before they ceased to form an essential part of academical instruction; thus affording an additional confirmation of Mr Smith's complaint, that the greater part of universities have not been very forward to adopt improvements after they were made; and that several of those learned societies have chosen to remain, for a long time, the sanctuaries in which exploded systems found shelter and protection, after they had been hunted out of every other corner of the world.” Considering his own successful exertions in his academical capacity, to remedy this evil, it is more than probable that Mr Smith had Grotius and Puffendorff in his view when he wrote the foregoing sentence.

The extravagance of the praise lavished on Grotius and Puffendorff, in the above citation from Carmichael, can be accounted for only by the degraded state into which Ethics had fallen in the hands of those who were led to the study of it, either as a preparation for the casuistical discussions subservient to the practice of auricular confession, or to justify a scheme of morality which recommended the useless austerities of an ascetic retirement, in preference to the manly duties of social life. The practical doctrines inculcated by the writers on Natural Law, were all of them favourable to active virtue; and, how reprehensible soever in point of form, were not only harmless, but highly beneficial in their tendency. They were at the same time so diversified (particularly in the work of Grotius) with beautiful quotations from the Greek and Roman classics, that they could not fail to present a striking contrast to the absurd and illiberal systems which they supplanted; and perhaps to these passages, to which they thus gave a sort of systematical connection, the progress which the science made in the course of the eighteenth century may, in no inconsiderable degree, be ascribed. Even now, when so very different a taste prevails, the treatise *de Jure Belli et Pacis* possesses many charms to a classical reader; who, although he may not always set a very high value on the author's reasonings, must at least be dazzled and delighted with the splendid profusion of his learning.

The field of Natural Jurisprudence, however, was not long to remain circumscribed within the narrow limits commonly assigned to the province of Ethics. The contrast between natural law and positive institution, which it constantly presents to the mind, gradually and insensibly suggested the idea of comprehending under it every question concerning right and wrong, on which positive law is silent. Hence the origin of two different departments of Jurisprudence, little attended to by some of the first authors who treated of it, but afterwards, from their practical importance, gradually encroaching more and more on those ethical disquisitions by which they were suggested. Of these departments, the one refers to the conduct of individuals in those violent and critical moments when the bonds of political society are torn asunder; the other, to the mutual relations of independent communities. The questions connected with the former article, lie indeed within a comparatively narrow compass; but on the latter so much has been written, that what was formerly called Natural Jurisprudence, has been, in later times, not unfrequently distinguished by the title of the *Law of Nature and Nations.* The train of thought by which both subjects came to be connected with the systems now under consideration, consists of a few very simple and obvious steps.

As an individual who is a member of a political body necessarily gives up his will to that of the governors who are entrusted by the people with the supreme power, it is his duty to submit to those inconveniences which, in consequence of the imperfection of all human establishments, may incidentally fall to his own lot. This duty is founded on the Law of Nature, from which, indeed, (as must appear evident on the slightest reflection) conventional law derives all its *moral* force and obligation. The great end, however, of the political union being a sense of general utility, if this end should be manifestly frustrated, either by the injustice of laws, or the tyranny of rulers, individuals must have recourse to the principles of Natural Law, in order to determine how far it is competent for them to withdraw themselves from their country, or to resist its governors by force. To Jurisprudence, therefore, considered in this light, came with great propriety to be referred all those practical discussions which relate to the limits of allegiance, and the right of resistance.

By a step equally simple, the province of the science was still farther extended. As independent states acknowledge no superior, the obvious inference was, that the disputes arising among them must be determined by an appeal to the Law of Nature; and accordingly, this law, when applied to states, forms a separate part of Jurisprudence, under the title of the Law of Nations. By some writers we are told, that the general principles of the Law of Nature, and of the Law of Nations, are one and the same, and that the distinction between them is merely verbal. To this opinion, which is very confidently stated by Hobbes,[1] Puffendorff has given his sanction; and in conformity to it, contents himself with laying down the general principles of Natural Law, leaving it to the reader to apply it as he may find necessary, to individuals or to societies.

The later writers on Jurisprudence have thought it expedient to separate the law of nations from that part of the science which treats of the duties of individuals;[2] but without being at sufficient pains to form to themselves a definite idea of the object of their studies. Whoever takes the trouble to look into their systems, will immediately perceive, that their leading aim is not, as might have been expected, to ascertain the great principles of morality binding on all nations in their intercourse with each other; or to point out with what limitations the ethical rules recognised among individuals must be understood, when extended to political and unconnected bodies; but to exhibit a digest of those laws and usages, which, partly from considerations of utility, partly from accidental circumstances, and partly from positive conventions, have gradually arisen among those states of Christendom, which, from their mutual connections, may be considered as forming one great republic. It is evident, that such a digest has no more connection with the Law of Nature, properly so called, than it has with the rules of the Roman Law, or of any other municipal code. The details contained in it are highly interesting and useful in themselves; but they belong to a science altogether different; a science, in which the ultimate appeal is made, not to abstract maxims of right and wrong, but to precedents, to established customs, and to the authority of the learned.

The intimate alliance, however, thus established between the Law of Nature and the conventional Law of Nations, has been on the whole attended with fortunate effects. In consequence of the discussions concerning questions of justice and of expediency which came to be blended with the details of public law, more enlarged and philosophical views have gradually presented themselves to the minds of speculative statesmen; and, in the last result, have led, by easy steps, to those liberal doctrines concerning commercial policy, and the other mutual relations of separate and independent states, which, if they should ever become the creed of the rulers of mankind, promise so large an accession to human happiness.

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[1] "Lex Naturalis dividi potest in naturalem hominum quæ sola obtinuit dici Lex Naturæ, et naturalem civitatum quæ dici potest Lex Gentium, vulgo autem Jus Gentium appellatur. Præcepta utriusque eadem sunt; sed quia civitates semel institutæ induunt proprietates hominum personales, lex quam loquentes de hominum singulorum officio naturalem dicimus, applicata totis civitatibus, nationibus, sive gentibus, vocatur Jus Gentium."—*De Cive*, cap. xiv. § 4.

In a late publication, from the title of which some attention to dates might have been expected, we are told, that "Hobbes's book *De Cive* appeared but a little time *before* the treatise of Grotius;" whereas, in point of fact, Hobbes's book did not *appear* till twenty-two years *after* it. A few copies were indeed printed at Paris, and privately circulated by Hobbes, as early as 1642, but the book was not published till 1647.—(See "*An Inquiry into the Foundation and History of the Law of Nations in Europe*," &c. by Robert Ward of the Inner Temple, Esq. London, 1795). This inaccuracy, however, is trifling, when compared with those committed in the same work, in stating the distinguishing doctrines of the two systems.

As a writer on the Law of Nations, Hobbes is now altogether unworthy of notice. I shall therefore only remark on this part of his philosophy, that its aim is precisely the *reverse* of that of Grotius; the latter labouring, through the whole of his treatise, to extend, as far as possible, among independent states, the same laws of justice and of humanity which are universally recognised among individuals; while Hobbes, by *inverting* the argument, exerts his ingenuity to shew, that the moral repulsion which commonly exists between independent and neighbouring communities, is an exact picture of that which existed among individuals prior to the origin of government. The inference, indeed, was most illogical, inasmuch as it is the social attraction among individuals which is the source of the mutual repulsion among nations, and as this attraction invariably operates with the greatest force where the individual is the most completely independent of his species, and where the advantages of the political union are the least sensibly felt. If, in any state of human nature, it be in danger of becoming quite evanescent, it is in large and civilised empires, where man becomes indispensably necessary to man, depending for the gratification of his artificial wants on the co-operation of thousands of his fellow citizens.

Let me add, that the theory so fashionable at present, which resolves the whole of morality into the principle of *utility*, is more nearly akin to Hobbism, than some of its partisans are aware of.

[2] The credit of this improvement is ascribed by Vattel (one of the most esteemed writers on the subject), to the celebrated German philosopher Wolfius, whose labours in this department of study he estimates very highly.—(*Questions de Droit Naturel.* Berne, 1762.) Of this great work I know nothing but the title, which is not calculated to excite much curiosity in the present times: "Christiani Wolfii *Jus Naturæ methodo scientifica pertractatum*, in 9 Tomos distributum." (Francof. 1740.) "Non est," says Lampredi, *himself* a professor of public law, "qui non deterreatur tanta librorum farragine, quasi vero Herculeo labore opus esset ut quis honestatem et justitiam addiscat."

3. Another idea of Natural Jurisprudence, essentially distinct from those hitherto mentioned, remains to be considered. According to this, its object is to ascertain the general principles of justice which *ought to be* recognised in every municipal code; and to which it *ought to be* the aim of every legislator to accommodate his institutions. It is to this idea of Jurisprudence that Mr Smith has given his sanction in the conclusion of his Theory of Moral Sentiments; and this he seems to have conceived to have been likewise the idea of Grotius, in the treatise *de Jure Belli et Pacis.*

" It might have been expected," says Mr Smith, " that the reasonings of lawyers upon the different imperfections and improvements of the laws of different countries, should have given occasion to an inquiry into what were the natural rules of justice, independent of all positive institution. It might have been expected, that these reasonings should have led them to aim at establishing a system of what might properly be called Natural Jurisprudence, or *a theory of the principles which ought to run through, and to be the foundation of the laws of all nations.* But, though the reasonings of lawyers did produce something of this kind, and though no man has treated systematically of the laws of any particular country, without intermixing in his work many observations of this sort, it was very late in the world before any such general system was thought of, or before the philosophy of laws was treated of by itself, and without regard to the particular institutions of any nation. Grotius seems to have been the first who attempted to give the world any thing like a system of those principles which ought to run through, and be the foundation of the laws of all nations; and his Treatise of the Laws of Peace and War, with all its imperfections, is perhaps, at this day, the most complete work that has yet been given on the subject."

Whether this was, or was not, the leading object of Grotius, it is not material to decide; but if this *was* his object, it will not be disputed that he has executed his design in a very desultory manner, and that he often seems to have lost sight of it altogether, in the midst of those miscellaneous speculations on political, ethical, and historical subjects, which form so large a portion of his Treatise, and which so frequently succeed each other without any apparent connection or common aim.[1]

Nor do the views of Grotius appear always enlarged or just, even when he is pointing at the object described by Mr Smith. The Roman system of Jurisprudence seems to have warped, in no inconsiderable degree, his notions on all questions connected with the theory of legislation, and to have diverted his attention from that philosophical idea of law, so well expressed by Cicero,—" Non a prætoris edicto, neque a duodecim tabulis, sed penitus ex intima philosophia, hauriendam juris disciplinam." In this idolatry, indeed, of the Roman law, he has not gone so far as some of his commentators, who have affirmed, that it is only a different name for the Law of Nature; but that his partiality for his professional pursuits has often led him to overlook the immense difference between the state of society in ancient and modern Europe, will not, I believe, be now disputed. It must, at the same time, be mentioned to his praise, that no writer appears to have been, *in theory*, more completely aware of the essential distinction between Natural and Municipal laws. In one of the paragraphs of his *Prolegomena*, he mentions it as a part of his general plan, to illustrate the Roman code, and to systematise those parts of it which have their origin in the Law of Nature. " The task," says he, " of moulding it into the form of a system, has been projected by many, but hitherto accomplished by none. Nor indeed was the thing possible, while so little attention was paid to the distinction between natural and positive institutions; for the former being everywhere the same, may be easily traced to a few general principles, while the latter, exhibiting different appearances at different times, and in different places, elude every attempt towards methodical arrangement, no less than the insulated facts which individual objects present to our external senses."

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[1] " Of what stamp," says a most ingenious and original thinker, " are the works of Grotius, Puffendorff, and Burlamaqui? Are they political or ethical, historical or juridical, expository or censorial?—Sometimes one thing, sometimes another: they seem hardly to have settled the matter with themselves."—BENTHAM's *Introduction to the Principles of Morals and Legislation*, p. 327.

This passage of Grotius has given great offence to two of the most eminent of his commentators, Henry and Samuel de Cocceii, who have laboured much to vindicate the Roman legislators against that indirect censure which the words of Grotius appear to convey. "My chief object," says the latter of those writers, "was, by deducing the Roman Law from its source in the nature of things, to reconcile Natural Jurisprudence with the civil code; and, at the same time, to correct the supposition implied in the foregoing passage of Grotius, which is indeed one of the most exceptionable to be found in his work. The remarks on this subject, scattered over the following commentary, the reader will find arranged in due order in my twelfth Preliminary Dissertation, the chief design of which is to systematise the whole Roman Law, and to demonstrate its beautiful coincidence with the Law of Nature." In the execution of this design, Coccii must, I think, be allowed to have contributed a very useful supplement to the jurisprudential labours of Grotius, the Dissertation in question being eminently distinguished by that distinct and luminous method, the want of which renders the study of the treatise *de Jure Belli et Pacis* so peculiarly irksome and unsatisfactory.

The superstitious veneration for the Roman code expressed by such writers as the Cocceii, will appear less wonderful, when we attend to the influence of the same prejudice on the liberal and philosophical mind of Leibnitz; an author who has not only gone so far as to compare the civil law (considered as a monument of human genius) with the remains of the ancient Greek geometry; but has strongly intimated his dissent from the opinions of those who have represented its principles as being frequently at variance with the Law of Nature. In one very powerful paragraph, he expresses himself thus:—"I have often said, that, after the writings of geometricians, there exists nothing which, in point of strength, subtlety, and depth, can be compared to the works of the Roman lawyers. And as it would be scarcely possible, from mere intrinsic evidence, to distinguish a demonstration of Euclid's from one of Archimedes or of Appollonius (the style of all of them appearing no less uniform than if reason herself were speaking through their organs), so also the Roman lawyers all resemble each other like twin-brothers; inasmuch that, from the style alone of any particular opinion or argument, hardly any conjecture could be formed about its author. Nor are the traces of a refined and deeply meditated system of Natural Jurisprudence anywhere to be found more visible, or in greater abundance. And even in those cases where its principles are departed from, either in compliance with the language consecrated by technical forms, or in consequence of new statutes, or of ancient traditions, the conclusions which the assumed hypothesis renders it necessary to incorporate with the eternal dictates of right reason, are deduced with the soundest logic, and with an ingenuity that excites admiration. *Nor are these deviations from the Law of Nature so frequent as is commonly apprehended.*"

In the last sentence of this passage, Leibnitz had probably an eye to the works of Grotius and his followers; which, however narrow and timid in their views they may now appear, were, for a long time, regarded among civilians as savouring somewhat of theoretical innovation, and of political heresy.

To all this may be added, as a defect still more important and radical in the systems of Natural Jurisprudence considered as models of universal legislation, that their authors reason concerning laws too abstractedly, without specifying the particular circumstances of the society to which they mean that their conclusions should be applied. It is very justly observed by Mr Bentham, that "if there are any books of universal Jurisprudence, they must be looked for within very narrow limits." He certainly, however, carries this idea too far, when he asserts, that "to be susceptible of an universal application, *all* that a book of the expository kind can have to treat of is *the import of words;* and that, to be strictly speaking universal, it must confine itself to terminology; that is, to an explanation of such words connected with law, as *power*, *right*, *obligation*, *liberty*, to which are words pretty exactly correspondent in all languages."[1] His expressions, too, are somewhat unguarded, when he calls the *Law of Nature* "an obscure phantom, which in the imaginations of those who go in chase of it, points sometimes to *manners*, sometimes to *laws*, sometimes to what law *is*, sometimes to what it *ought to be*."[2] Nothing, indeed, can be more exact and judicious than this description, when restricted to the *Law of Nature*, as commonly treated of by writers on Jurisprudence; but if extended to the *Law of Nature*, as originally understood among ethical writers, it is impossible to assent to it, without abandoning all the principles on which the science of morals ultimately rests. With these obvious, but, in my opinion, very essential limitations, I perfectly agree with Mr Bentham, in considering an abstract code of laws as a thing equally unphilosophical in the design, and useless in the execution.

In stating these observations, I would not be understood to dispute the utility of turning the attention of students to a comparative view of the municipal institutions of different nations; but only to express my doubts whether this can be done with advantage, by referring these institutions to that abstract theory called the *Law of Nature*, as to a common standard. The code of some particular country must be fixed on as a groundwork for our speculations; and its laws studied, not as consequences of any abstract principles of justice, but in their connection with the circumstances of the people among whom they originated. A comparison of these laws with the corresponding laws of other nations, considered also in their connection with the circumstances whence they arose, would form a branch of study equally interesting and useful, not merely to those who have in view the profession of law, but to all who receive the advantages of a liberal education. In fixing on such a standard, the preference must undoubtedly be given to the Roman Law, if for no other reason than this, that its technical language is more or less incorporated with all our municipal regulations in this part of the world: and the study of this language, as well as of the other technical parts of Jurisprudence (so revolting to the taste when considered as the arbitrary jargon of a philosophical theory), would possess sufficient attractions to excite the curiosity, when considered as a necessary passport to a knowledge of that system which so long determined the rights of the greatest and most celebrated of nations.

"Universal grammar," says Dr Lowth, "cannot be taught abstractedly; it must be done with reference to some language already known, in which the terms are to be explained and the rules exemplified."[3] The same observation may be applied (and for reasons strikingly analogous) to the science of Natural or Universal Jurisprudence.

Of the truth of this last proposition Bacon seems to have been fully aware; and it was manifestly some ideas of the same kind which gave birth to Montesquieu's historical speculations with respect to the origin of laws, and the reference which they may be expected to bear, in different parts of the world, to the physical and moral circumstances of the nations among whom they have sprung up. During this long interval, it would be difficult to name any intermediate writer, by whom the important considerations just stated were duly attended to.

In touching formerly on some of Bacon's ideas concerning the philosophy of law, I quoted a few of the most prominent of those fortunate anticipations, so profusely scattered over his works, which, outstripping the ordinary march of human reason, associate his mind with the luminaries of the eighteenth century, rather than with his own contemporaries. These anticipations, as well as many others of a similar description, hazarded by his bold yet prophetic imagination, have often struck me as resembling the *pierres d'attente* jutting out from the corners of an ancient building, and inviting the fancy to complete what was left unfinished of the architect's design;—or the slight and broken sketches traced on the skirts of an American map, to connect its chains of hills and branches of rivers with some future survey of the contiguous wilderness. Yielding to such impressions, and eager to pursue the rapid flight of his genius, let me abandon for a moment the order of time, while I pass from the *Fontes Juris* to the *Spirit of Laws*. To have a just conception of the comparatively limited views of Grotius, it is necessary to attend to what was planned by his immediate predecessor, and first executed (or rather first *begun* to be executed) by one of his remote successors.

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[1] *Introduction to the Principles of Morals and Legislation*, p. 323.

[2] *Ibid.* p. 327.

[3] Preface to his *English Grammar.*

The main object of the *Spirit of Laws* (it is necessary here to premise) is to show, not, as has been frequently supposed, what laws *ought* to be, but how the diversities in the physical and moral circumstances of the human race have contributed to produce diversities in their political establishments, and in their municipal regulations.[1] On this point, indeed, an appeal may be made to the author himself. "I write not," says he, "to censure any thing established in any country whatsoever; every nation will here find the *reasons* on which its maxims are founded." This plan, however, which, when understood with proper limitations, is highly philosophical, and which raises Jurisprudence, from the uninteresting and useless state in which we find it in Grotius and Puffendorff, to be one of the most agreeable and important branches of useful knowledge (although the execution of it occupies by far the greater part of his work), is prosecuted by Montesquieu in so very desultory a manner, that I am inclined to think he rather fell into it insensibly, in consequence of the occasional impulse of accidental curiosity, than from any regular design he had formed to himself when he began to collect materials for that celebrated performance. He seems, indeed, to confess this in the following passage of his preface: "Often have I begun, and as often laid aside, this undertaking. I have followed my observations without any fixed plan, and without thinking either of rules or exceptions. I have found the truth only to lose it again."

But whatever opinion we may form on this point, Montesquieu enjoys an unquestionable claim to the grand idea of connecting Jurisprudence with History and Philosophy, in such a manner as to render them all subservient to their mutual illustration. Some occasional disquisitions of the same kind may, it is true, be traced in earlier writers, particularly in the works of Bodinus; but they are of a nature too trifling to detract from the glory of Montesquieu. When we compare the jurisprudential researches of the latter with the systems previously in possession of the schools, the step which he made appears to have been so vast as almost to justify the somewhat too ostentatious motto prefixed to them by the author; *Prolem sine Matre creatam.* Instead of confining himself, after the example of his predecessors, to an interpretation of one part of the Roman code by another, he studied the SPIRIT of these laws in the political views of their authors, and in the peculiar circumstances of that extraordinary race. He combined the science of law with the history of political society, employing the latter to account for the varying aims of the legislator; and the former, in its turn, to explain the nature of the government, and the manners of the people. Nor did he limit his inquiries to the Roman Law, and to Roman History; but, convinced that the general principles of human nature are everywhere the same, he searched for new lights among the subjects of every government, and the inhabitants of every climate; and, while he thus opened inexhaustible and unthought of resources to the student of Jurisprudence, he indirectly marked out to the legislator the extent and the limits of his power, and recalled the attention of the philosopher from abstract and useless theories, to the only authentic monuments of the history of mankind.[2]

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[1] This, though somewhat ambiguously expressed, *must*, I think, have been the idea of D'Alembert in the following sentence; "Dans cet ouvrage, M. de Montesquieu s'occupe moins des loix qu'on a faites, que de celles qu'on a du faire."—(*Eloge de M. de Montesquieu.*) According to the most obvious interpretation of his words, they convey a meaning which I conceive to be the very reverse of the truth.

[2] As examples of Montesquieu's peculiar and characteristical style of thinking in *The Spirit of Laws*, may be mentioned his *Observations on the Origin and Revolutions of the Roman Laws on Successions*; and what he has written on the *History of the Civil Laws in his own Country*; above all, his *Theory of the Feudal Laws among the Franks*, considered in relation to the re-

This view of law, which unites History and Philosophy with Jurisprudence, has been followed out with remarkable success by various authors since Montesquieu's time; and for a considerable number of years after the publication of the *Spirit of Laws*, became so very fashionable, particularly in this country, that many seem to have considered it, *not* as a step towards a farther end, but as exhausting the whole science of Jurisprudence. For such a conclusion there is undoubtedly some foundation, so long as we confine our attention to the ruder periods of society, in which governments and laws may be universally regarded as the gradual result of time and experience, of circumstances and emergencies. In enlightened ages, however, there cannot be a doubt, that political wisdom comes in for its share in the administration of human affairs; and there is reasonable ground for hoping, that its influence will continue to increase, in proportion as the principles of legislation are more generally studied and understood. To suppose the contrary, would reduce us to be mere *spectators* of the progress and decline of society, and put an end to every species of patriotic exertion.

Montesquieu's own aim in his historical disquisitions, was obviously much more deep and refined. In various instances, one would almost think he had in his mind the very shrewd aphorism of Lord Coke, that, "to trace an error to its fountain-head, is to refute it;"—a species of refutation, which, as Mr Bentham has well remarked, is, with many understandings, the only one that has any weight.[1] To men prepossessed with a blind veneration for the wisdom of antiquity, and strongly impressed with a conviction that every thing they see around them is the result of the legislative wisdom of their ancestors, the very existence of a legal principle, or of an established custom, becomes an argument in its favour; and an argument to which no reply can be made, but by tracing it to some acknowledged prejudice, or to a form of society so different from that existing at present, that the same considerations which serve to account for its first origin, demonstrate indirectly the expediency of now accommodating it to the actual circumstances of mankind.

According to this view of the subject, the speculations of Montesquieu were ultimately directed to the same practical conclusion with that pointed out in the prophetic suggestions of Bacon; aiming, however, at this object, by a process more circuitous; and, perhaps, on that account, the more likely to be effectual. The plans of both have been since combined with extraordinary sagacity, by some of the later writers on Political Economy;[2] but with *their* systems we have no concern in the present section. I shall therefore only remark, in addition to the foregoing observations, the peculiar utility of these researches concerning the *history* of laws, in repressing the folly of sudden and violent innovation, by illustrating the reference which laws must necessarily have to the actual circumstances of a people,—and the tendency which natural causes have to improve gradually and progressively the condition of mankind, under every government which allows them to enjoy the blessings of peace and of liberty.

The well-merited popularity of the *Spirit of Laws*, gave the first fatal blow to the study of *Natural Jurisprudence;* partly by the proofs

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volutions of their monarchy. On many points connected with these researches, his conclusions have been since controverted; but all his successors have agreed in acknowledging *him* as their common master and guide.

[1] "*If our ancestors have been all along under a mistake, how came they to have fallen into it?* is a question that naturally occurs upon all such occasions. The case is, that, in matters of law more especially, such is the dominion of authority over our minds, and such the prejudice it creates in favour of whatever institution it has taken under its wing, that, after all manner of reasons that can be thought of in favour of the institution have been shewn to be insufficient, we still cannot forbear looking to some unassignable and latent reason for its efficient cause. But if, instead of any such reason, we can find a cause for it in some notion, of the erroneousness of which we are already satisfied, then at last we are content to give it up without farther struggle; and then, and not till then, our satisfaction is complete."—*Defence of Usury*, pp. 94, 95.

[2] Above all, by Mr Smith; who, in his *Wealth of Nations*, has judiciously and skilfully combined with the investigation of general principles, the most luminous sketches of *theoretical history* relative to that form of political society which has given birth to so many of the institutions and customs peculiar to modern Europe.—"The strong ray of philosophic light on this interesting subject," which, according to Gibbon, "broke from Scotland in our times," was but a *reflection*, though with a far steadier and more concentrated force, from the scattered but brilliant sparks kindled by the genius of Montesquieu. I shall afterwards have occasion to take notice of the mighty influence which his writings have had on the subsequent history of Scottish literature.

which, in every page, the work afforded, of the absurdity of all schemes of Universal Legislation; and partly by the attractions which it possessed, in point of eloquence and taste, when contrasted with the insupportable dulness of the systems then in possession of the schools. It is remarkable, that Montesquieu has never once mentioned the name of Grotius;—in *this*, probably, as in numberless other instances, conceiving it to be less expedient to attack established prejudices openly and in front, than gradually to undermine the unsuspected errors upon which they rest.

If the foregoing details should appear tedious to some of my readers, I must request them to recollect, that they relate to a science which, for much more than a hundred years, constituted the whole of philosophy, both ethical and political, of the largest portion of civilised Europe. With respect to Germany, in particular, it appears from the Count de Hertzberg, that this science continued to maintain its undisputed ground, till it was supplanted by that growing passion for Statistical details, which, of late, has given a direction so different, and in some respects so opposite, to the studies of his countrymen.[1]

When from Germany we turn our eyes to the south of Europe, the prospect seems not merely sterile, but afflicting and almost hopeless. Of Spanish literature I know nothing but through the medium of Translations; a very imperfect one, undoubtedly, when a judgment is to be passed on compositions addressed to the powers of imagination and taste; yet fully sufficient to enable us to form an estimate of works which treat of science and philosophy. On such subjects, it may be safely concluded, that whatever is unfit to stand the test of a literal version, is not worth the trouble of being studied in the original. The progress of the Mind in Spain during the seventeenth century, we may therefore confidently pronounce, if not entirely suspended, to have been too inconsiderable to merit attention.

"The only good book," says Montesquieu, "which the Spaniards have to boast of, is that which exposes the absurdity of all the rest." In this remark, I have little doubt that there is a considerable sacrifice of truth to the pointed effect of an antithesis. The unqualified censure, at the same time, of this great man, is not unworthy of notice, as a strong expression of his feelings with respect to the general insignificance of the Spanish writers.[2]

The inimitable work here referred to by Montesquieu, is itself entitled to a place in this Discourse, not only as one of the happiest and most wonderful creations of human fancy, but as the record of a force of character, and an enlargement of mind, which, when contrasted with the prejudices of the author's age and nation, seem almost miraculous. It is not merely against Books of Chivalry that the satire of Cervantes is directed. Many other follies and absurdities of a less local and temporary nature have their share in his ridicule; while not a single expression escapes his pen that can give offence to the most fastidious moralist. Hence those amusing and interesting contrasts by which Cervantes so powerfully attaches us to the hero of his story; chastising the wildest freaks of a disordered imagination, by a stateliness yet courtesy of virtue, and (on all subjects but one) by a superiority of good sense and of philosophical refinement, which, even under the most ludicrous circumstances, never cease to command our respect, and to keep alive our sympathy.

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[1] "La connoissance des états qu'on se plait aujourd'hui d'appeller *Statistique*, est une de ces sciences qui sont devenues à la mode, et qui ont pris une vogue générale depuis quelques années; elle a presque dépossédé celle du Droit Public, qui régnoit au commencement et jusques vers le milieu du siècle présent."—*Reflexions sur la Force des Etats.* Par M. le Comte de Hertzberg. Berlin, 1782.

[2] "Lord Bolingbroke told Mr Spence, as he informs us in his Anecdotes, that Dryden assured him, he was more indebted to the Spanish critics, than to the writers of any other nation."—(MALONE, *in a Note on Dryden's Essay on Dramatic Poesy.*

The same anecdote is told, though with a considerable difference in the circumstances, by Warton, in his Essay on the writings of Pope. "Lord Bolingbroke assured Pope, that Dryden often declared to him, that he got more from the Spanish critics, than from the Italian, French, and all other critics put together."

I suspect that there is some mistake in this story. A Spanish gentleman, equally well acquainted with the literature of his own country and with that of England, assures me, that he cannot recollect a single Spanish critic from whom Dryden can reasonably be supposed to have derived any important lights.

In Italy, notwithstanding the persecution undergone by Galileo, Physics and Astronomy continued to be cultivated with success by Torricelli, Borelli, Cassini, and others; and in pure Geometry, Viviani rose to the very first eminence, as the Restorer, or rather as the Diviner of ancient discoveries , but, in all those studies which require the animating spirit of civil and religious liberty, this once renowned country exhibited the most melancholy symptoms of mental decrepitude. "Rome," says a French historian, "was too much interested in maintaining her principles, not to raise every imaginable barrier against what might destroy them. Hence that *Index* of prohibited books, into which were put the history of the President de Thou; the works on the liberties of the Gallican church; and (who could have believed it?) the translations of the Holy Scriptures. Meanwhile, this tribunal, though always ready to condemn judicious authors upon frivolous suspicions of heresy, approved those seditious and fanatical theologists, whose writings tended to the encouragement of regicide, and the destruction of government. The approbation and censure of books (it is justly added) deserves a place in the history of the human mind."

The great glory of the Continent towards the end of the seventeenth century (I except only the philosophers of France) was Leibnitz. He was born as early as 1646, and distinguished himself, while still a very young man, by a display of those talents which were afterwards to contend with the united powers of Clarke and of Newton. I have already introduced his name among the writers on Natural Law; but, in every other respect, he ranks more fitly with the contemporaries of his old age than with those of his youth. My reasons for thinking so will appear in the sequel. In the meantime, it may suffice to remark, that Leibnitz, the Jurist, belongs to one century, and Leibnitz, the Philosopher, to another.

In this, and other analogous distributions of my materials, as well as in the order I have followed in the arrangement of particular facts, it may be proper, once for all, to observe, that much must necessarily be left to the *discretionary*, though not to the *arbitrary* decision of the author's judgment;—that the dates which separate from each other the different stages in the progress of Human Reason, do not, like those which occur in the history of the exact sciences, admit of being fixed with chronological and indisputable precision; while, in adjusting the perplexed rights of the innumerable claimants in this intellectual and shadowy region, a task is imposed on the writer, resembling not unfrequently the labour of *him*, who should have attempted to circumscribe, by mathematical lines, the melting and intermingling colours of Arachne's web;

> In quo diversi niteant cum mille colores,
> Transitus ipse tamen spectantia lumina fallit;
> Usque adeo quod tangit idem est, tamen ultima distant.

But I will not add to the number (already too great) of the foregoing pages, by anticipating, and attempting to obviate, the criticisms to which they may be liable. Nor will I dissemble the confidence with which, amid a variety of doubts and misgivings, I look forward to the candid indulgence of those who are best fitted to appreciate the difficulties of my undertaking. I am certainly not prepared to say with Johnson, that "I dismiss my work with frigid indifference, and that to me success and miscarriage are empty sounds." My feelings are more in unison with those expressed by the same writer in the conclusion of the admirable preface to his edition of Shakspeare. One of his reflections, more particularly, falls in so completely with the train of my own thoughts, that I cannot forbear, before laying down the pen, to offer it to the consideration of my readers.

"Perhaps I may not be more censured for doing wrong, than for doing little; for raising in the public, expectations which at last I have not answered. The expectation of ignorance is indefinite, and that of knowledge is often tyrannical. It is hard to satisfy those who know not what to demand, or those who demand by design what they think impossible to be done.'

DISSERTATION FIRST.

PART SECOND.

In the farther prosecution of the plan of which I traced the outline in the Preface to the First Part of this Dissertation, I find it necessary to depart considerably from the arrangement which I adopted in treating of the Philosophy of the seventeenth century. During that period, the literary intercourse between the different nations of Europe was comparatively so slight, that it seemed advisable to consider, separately and successively, the progress of the mind in England, in France, and in Germany. But from the era at which we are now arrived, *the Republic of Letters* may be justly understood to comprehend, not only these and other countries in their neighbourhood, but every region of the civilised earth. Disregarding, accordingly, all diversities of language and of geographical situation, I shall direct my attention to the intellectual progress of the species in general; enlarging, however, chiefly on the Philosophy of those parts of Europe, from whence the rays of science have, in modern times, diverged to the other quarters of the globe. I propose also, in consequence of the thickening crowd of useful authors, keeping pace in their numbers with the diffusion of knowledge and of liberality, to allot separate discourses to the history of Metaphysics, of Ethics, and of Politics; a distribution which, while it promises a more distinct and connected view of these different subjects, will furnish convenient resting-places, both to the writer and to the reader, and can scarcely fail to place, in a stronger and more concentrated light, whatever general conclusions may occur in the course of this survey.

The foregoing considerations, combined with the narrow limits assigned to the sequel of my work, will sufficiently account for the contracted scale of some of the following sketches, when compared with the magnitude of the questions to which they relate, and the peculiar interest which they derive from their immediate influence on the opinions of our own times.

In the case of Locke and Leibnitz, with whom the metaphysical history of the eighteenth century opens, I mean to allow myself a greater degree of latitude. The rank which I have assigned to both in my general plan seems to require, of course, a more ample space for their leading doctrines, as well as for those of some of their contemporaries and immediate successors, than I can spare for metaphysical systems of a more modern date; and as the rudiments of the most important of these are to be found in the speculations either of one or of the other, I shall endeavour, by connecting with my review of their works, those longer and more abstract discussions which are necessary for the illustration of fundamental principles, to avoid, as far as possible, in the remaining part of my discourse, any tedious digressions into the thorny paths of scholastic controversy. The critical remarks, accordingly, which I am now to offer on their philosophical writings, will, I trust, enable me to execute the very slight sketches which are to follow, in a manner at once more easy to myself, and more satisfactory to the bulk of my readers.

But what I have chiefly in view in these preliminary observations, is to correct certain misapprehensions concerning the opinions of Locke and of Leibnitz, which have misled (with very few exceptions) all the later historians who have treated of the literature of the eighteenth century. I have felt a more particular solicitude to vindicate the fame of Locke, not only against the censures of his opponents, but against the mistaken comments and eulogies of his admirers, both in England and on the Continent. Appeals to his authority are so frequent in the reasonings of all who have since canvassed the same subjects, that, without a precise idea of his distinguishing tenets, it is impossible to form a just estimate, either of the merits or demerits of his successors. In order to assist my readers in this previous study, I shall endeavour, as far as I can, to make Locke his own commentator; earnestly entreating them, before they proceed to the sequel of this dissertation, to collate carefully those scattered extracts from his works, which, in the following section, they will find brought into contact with each other, with a view to their mutual illustration. My own conviction, I confess, is, that the *Essay on Human Understanding* has been much more generally applauded than read; and if I could only flatter myself with the hope of drawing the attention of the public from the glosses of commentators to the author's text, I should think that I had made a considerable step towards the correction of some radical and prevailing errors, which the supposed sanction of his name has hitherto sheltered from a free examination.

PROGRESS OF METAPHYSICS DURING THE EIGHTEENTH CENTURY.

SECTION I.

Historical and Critical Review of the Philosophical Works of Locke and Leibnitz.

LOCKE.

Before entering on the subject of this section, it is proper to premise, that, although my design is to treat separately of Metaphysics, Ethics, and Politics, it will be impossible to keep these sciences wholly unmixed in the course of my reflections. They all run into each other by insensible gradations; and they have all been happily united in the comprehensive speculations of some of the most distinguished writers of the eighteenth century. The connection between Metaphysics and Ethics is more peculiarly close; the theory of Morals having furnished, ever since the time of Cudworth, several of the most abstruse questions which have been agitated concerning the general principles, both intellectual and active, of the human frame. The inseparable affinity, however, between the different branches of the Philosophy of the Mind, does not afford any argument against the arrangement which I have adopted. It only shows, that it cannot, in every instance, be rigorously adhered to. It shall be my aim to deviate from it as seldom, and as slightly, as the miscellaneous nature of my materials will permit.

John Locke, from the publication of whose *Essay on Human Understanding* a new era is to be dated in the History of Philosophy, was born at Wrington in Somersetshire, in 1632. Of his father nothing remarkable is recorded, but that he was a captain in the Parliament's army during the civil wars; a circumstance which, it may be presumed from the son's political opinions, would not be regarded by him as a stain on the memory of his parent.

In the earlier part of Mr Locke's life, he prosecuted for some years, with great ardour, the study of medicine; an art, however, which he never actually exercised as a profession. According to his friend Le Clerc, the delicacy of his constitution rendered this impossible. But, that his proficiency in the study was not inconsiderable, we have good evidence in the dedication prefixed to Dr Sydenham's *Observations on the History and Cure of Acute Diseases*;[1] where he boasts of the approbation bestowed on his METHOD by Mr John Locke, who (to borrow Sydenham's own words) "examined it to the bottom; and who, if we consider his genius and penetrating and exact judgment, has scarce any superior, and few equals, now living." The merit of this METHOD, therefore, which still continues to be regarded as a model by the most competent judges, may be presumed to have belonged *in part* to Mr Locke,[2]—a circumstance which deserves to be noticed, as an additional confirmation of what Bacon has so sagaciously taught, concerning the dependence of all the sciences relating to the phenomena, either of Matter or of Mind, on principles and rules derived from the resources of a higher philosophy. On the other hand, no science could have been chosen, more happily calculated than Medicine, to prepare such a mind as that of Locke for the prosecution of those speculations which have immortalised his name; the complicated, and fugitive, and often equivocal phenomena of disease, requiring in the observer a far greater portion of discriminating sagacity, than those of Physics, strictly so called; resembling, in this respect, much more nearly, the phenomena about which Metaphysics, Ethics, and Politics, are conversant.

I have said, that the study of Medicine forms one of the best preparations for the study of Mind, *to such an understanding as Locke's*. To an understanding less comprehensive, and less cultivated by a liberal education, the effect of this study is likely to be similar to what we may trace in the works of Hartley, Darwin, and Cabanis; to all of whom we may more or less apply the sarcasm of Cicero on Aristoxenus, the Musician, who attempted to explain the nature of the soul by comparing it to a *Harmony*; HIC AB ARTIFICIO SUO NON RECESSIT.[3] In Locke's *Essay*, not a single passage occurs, savouring of the Anatomical Theatre, or of the Chemical Laboratory.

In 1666, Mr Locke, then in his thirty-fifth year, formed an intimate acquaintance with Lord Ashley, afterwards Earl of Shaftesbury; from which period a complete change took place, both in the direction of his studies, and in his habits of life. His attention appears to have been then turned, for the first time, to political subjects: and his place of residence transferred from the university to the metropolis. From London (a scene which gave him access to a society very different from what he had previously lived in)[4] he occasionally passed over to the Continent, where he had an opportunity of profiting by the conversation of some of the most distinguished persons of his age. In the course of his foreign excursions, he visited France, Germany, and Holland; but the last of these countries seems to have been his favourite place of residence; the blessings which the people there enjoyed, under a government peculiarly favourable to civil and religious liberty, amply compensat-

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[1] Published in the year 1676.

[2] It is remarked of Sydenham, by the late Dr John Gregory, "That though full of hypothetical reasoning, it had not the usual effect of making him less attentive to observation; and that his hypotheses seem to have sat so loosely about him, that either they did not influence his practice at all, or he could easily abandon them, whenever they would not bend to his experience."

This is precisely the idea of Locke concerning the true use of hypotheses. "Hypotheses, if they are well made, are at least great helps to the memory, and often direct us to new discoveries."—LOCKE'S *Works*, Vol. III. p. 81. See also some remarks on the same subject in one of his letters to Mr Molyneux. (The edition of Locke to which I uniformly refer, is that printed at London in 1812, in Ten Volumes 8vo.)

[3] Tusc. Quæst. Lib. 1.

[4] Villiers Duke of Buckingham, and the Lord Halifax, are particularly mentioned among those who were delighted with his conversation.

Adv. Bib.

ing, in his view, for what their uninviting territory wanted in point of scenery and of climate. In this respect, the coincidence between the taste of Locke and that of Descartes throws a pleasing light on the characters of both.

The plan of the *Essay on Human Understanding* is said to have been formed as early as 1670; but the various employments and avocations of the Author prevented him from finishing it till 1687, when he fortunately availed himself of the leisure which his exile in Holland afforded him, to complete his long meditated design. He returned to England soon after the Revolution, and published the first edition of his work in 1690; the busy and diversified scenes through which he had passed during its progress, having probably contributed, not less than the academical retirement in which he had spent his youth, to enhance its peculiar and characteristical merits.

Of the circumstances which gave occasion to this great and memorable undertaking, the following interesting account is given in the *Prefatory Epistle to the Reader.* "Five or six friends, meeting at my chamber, and discoursing on a subject very remote from this, found themselves quickly at a stand, by the difficulties that rose on every side. After we had a while puzzled ourselves, without coming any nearer a resolution of those doubts which perplexed us, it came into my thoughts that we took a wrong course, and that, before we set ourselves upon inquiries of that nature, it was necessary to examine our own abilities, and see what objects our understandings were, or were not, fitted to deal with. This I proposed to the company, who all readily assented, and thereupon it was agreed, that this should be our first inquiry. Some hasty and undigested thoughts on a subject I had never before considered, which I set down against our next meeting, gave the first entrance into this discourse, which having been thus begun by chance, was continued by entreaty; written by incoherent parcels, and, after long intervals of neglect, resumed again as my humour or occasions permitted; and at last in retirement, where an attendance on my health gave me leisure, it was brought into that order thou now seest it."

Mr Locke afterwards informs us, that "when he first put pen to paper, he thought all he should have to say on this matter would have been contained in one sheet, but that the farther he went the larger prospect he had;—new discoveries still leading him on, till his book grew insensibly to the bulk it now appears in."

On comparing the *Essay on Human Understanding* with the foregoing account of its origin and progress, it is curious to observe, that it is the fourth and last book alone which bears directly on the author's principal object. In this book, it is further remarkable, that there are few, if any references to the preceding parts of the Essay; insomuch that it might have been published separately, without being less intelligible than it is. Hence, it seems not unreasonable to conjecture, that it was the *first* part of the work in the order of composition, and that it contains those leading and fundamental thoughts which offered themselves to the author's mind, when he first began to reflect on the friendly conversation which gave rise to his philosophical researches. The inquiries in the first and second books, which are of a much more abstract, as well as scholastic nature, than the sequel of the work, probably opened gradually on the author's mind in proportion as he studied his subject with a closer and more continued attention. They relate chiefly to the origin and to the technical classification of our ideas, frequently branching out into *collateral*, and sometimes into *digressive* discussions, without much regard to method or connection. The third book (by far the most important of the whole), where the nature, the use, and the abuse of language are so clearly and happily illustrated, seems, from Locke's own account, to have been a sort of *after-thought;* and the two excellent chapters on the *Association of Ideas* and on *Enthusiasm* (the former of which has contributed, as much as any thing else in Locke's writings, to the subsequent progress of Metaphysical Philosophy, were printed, for the first time, in the fourth edition of the Essay.

I would not be understood, by these remarks, to undervalue the two first books. All that I have said amounts to this, that the subjects which they treat of are seldom susceptible of any practical application to the conduct of the understanding; and that the author has adopted a new phraseology of his own, where, in some instances, he might have much more clearly conveyed his meaning without any departure from the ordinary forms of speech. But although these considerations render the two first books inferior in point of general utility to the two last, they do not materially detract from their merit, as a precious accession to the theory of the Human Mind. On the contrary, I do not hesitate to consider them as the richest contribution of well-observed and well-described facts, which was ever bequeathed to this branch of science by a single individual, and as the indisputable, though not always acknowledged, source of some of the most refined conclusions, with respect to the intellectual phenomena, which have been since brought to light by succeeding inquirers.

After the details given by Locke himself, of the circumstances in which his Essay was begun and completed; more especially, after what he has stated of the "discontinued way of writing," imposed on him by the avocations of a busy and unsettled life, it cannot be thought surprising, that so very little of method should appear in the disposition of his materials; or that the opinions which, on different occasions, he has pronounced on the same subject, should not always seem perfectly steady and consistent. In these last cases, however, I am inclined to think that the inconsistencies, if duly reflected on, would be found rather apparent than real. It is but seldom that a writer possessed of the powerful and upright mind of Locke, can reasonably be suspected of stating propositions in direct contradiction to each other. The presumption is, that, in each of these propositions, there is a mixture of truth, and that the error lies chiefly in the unqualified manner in which the truth is stated; proper allowances not being made, during the fervour of composition, for the partial survey taken of the objects from a particular point of view. Perhaps it would not be going too far to assert, that most of the seeming contradictions which occur in authors animated with a sincere love of truth, might be fairly accounted for by the different aspects which the same object presented to them upon different occasions. In reading such authors, accordingly, when we meet with discordant expressions, instead of indulging ourselves in the captiousness of verbal criticism, it would better become us carefully and candidly to collate the questionable passages; and to study so to reconcile them by judicious modifications and corrections, as to render the oversights and mistakes of our illustrious guides subservient to the precision and soundness of our own conclusions. In the case of Locke, it must be owned, that this is not always an easy task, as the limitations of some of his most exceptionable propositions are to be collected, not from the context, but from different and widely separated parts of his Essay.[1]

In a work thus composed *by snatches* (to borrow a phrase of the author's), it was not to be expected, that he should be able accurately to draw the line between his own ideas, and the hints for which he was indebted to others. To those who are well acquainted with his speculations, it must appear evident, that he had studied diligently the metaphysical writings both of Hobbes and of Gassendi; and that he was no stranger to the *Essays* of Montaigne, to the philosophical works of Bacon, or to Malebranche's *Inquiry after Truth.*[2] That he was familiarly conversant with the Cartesian system may be presumed from what we are told by his biographer, that it was *this* which first inspired him with a disgust at the jargon of the schools, and led him into that train of thinking which he afterwards prosecuted so successfully. I do not, however, recollect that he has anywhere in his Essay mentioned the name of any one of these authors.[1] It is probable, that, when he sat down to write, he found the result of his youthful reading so completely identified with the fruits of his subsequent reflections, that it was impossible for him to attempt a separation of the one from the other; and that he was thus occasionally led to mistake the treasures of memory for those of invention. That this was really the case, may be farther presumed from the peculiar and original cast of his phraseology, which, though in general careless and unpolished, has always the merit of that characteristical unity and *raciness* of style, which demonstrate, that, while he was writing, he conceived himself to be drawing only from his own resources.

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[1] That Locke himself was sensible that some of his expressions required explanation, and was anxious that his opinions should be judged of rather from the general tone and spirit of his work, than from detached and isolated propositions, may be inferred from a passage in one of his notes, where he replies to the animadversions of one of his antagonists (the Reverend Mr Lowde), who had accused him of calling in question the immutability of moral distinctions. "But (says Locke) the good man does well, and as becomes his calling, to be watchful in such points, and to take the alarm, even at expressions which, standing alone by themselves, might sound ill, and be suspected."—(LOCKE'S *Works*, Vol. II. p. 93. Note.)

[2] Mr Addison has remarked, that Malebranche had the start of Locke, by several years, in his notions on the subject of *Duration*.—(Spectator, No. 94.) Some other coincidences, not less remarkable, might be easily pointed out in the opinions of the English and of the French philosopher.

With respect to his style, it may be further observed, that it resembles that of a well educated and well informed man of the world, rather than of a recluse student who had made an object of the art of composition. It everywhere abounds with colloquial expressions, which he had probably caught by the ear from those whom he considered as models of good conversation; and hence, though it now seems somewhat antiquated, and not altogether suited to the dignity of the subject, it may be presumed to have contributed its share towards his great object of turning the thoughts of his contemporaries to logical and metaphysical inquiries. The author of the *Characteristics*, who will not be accused of an undue partiality for Locke, acknowledges, in strong terms, the favourable reception which his book had met with among the higher classes. "I am not sorry, however," says Shaftesbury, to one of his correspondents, "that I lent you Locke's Essay, a book that may as well qualify men for business and the world, as for the sciences and a university. No one has done more towards the recalling of philosophy from barbarity, into use and practice of the world, and into the company of the better and politer sort, who might well be ashamed of it in its other dress. No one has opened a better and clearer way to reasoning."[2]

In a passage of one of Warburton's letters to Hurd, which I had occasion to quote in the first part of this Dissertation, it is stated as a fact, that, "when Locke first published his Essay, he had neither followers nor admirers, and hardly a single approver." I cannot help suspecting very strongly the correctness of this assertion, not only from the flattering terms in which the Essay is mentioned by Shaftesbury in the foregoing quotation, and from the frequent allusions to its doctrines by Addison and other popular writers of the same period, but from the unexampled sale of the book, during the fourteen years which elapsed between its publication and Locke's death. Four editions were printed in the space of ten years, and three others must have appeared in the space of the next four; a reference being made to the *sixth* edition by the author himself, in the epistle to the reader, prefixed to all the subsequent impressions. A copy of the thirteenth edition, printed as early as 1748, is now lying before me. So rapid and so extensive a circulation of a work, on a subject so little within the reach of common readers, is the best proof of the established popularity of the author's name, and of the respect generally entertained for his talents and his opinions.

That the *Essay on Human Understanding* should have excited some alarm in the University of Oxford, was no more than the author had reason to expect from his boldness as a philosophical reformer; from his avowed zeal in the cause of liberty, both civil and religious; from the suspected orthodoxy of his Theological Creed; and (it is but candid to add) from the apparent coincidence of his ethical doctrines with those of Hobbes.[1] It is more difficult to account for the long continuance, in that illustrious seat of learning, of the prejudice against the *logic* of Locke (by far the most valuable part of his work), and of that partiality for the logic of Aristotle, of which Locke has so fully exposed the futility. In the University of Cambridge, on the other hand, the *Essay on Human Understanding* was, for many years, regarded with a reverence approaching to idolatry; and to the authority of some distinguished persons connected with that learned body may be traced (as will afterwards appear) the origin of the greater part of the extravagancies which, towards the close of the last century, were grafted on Locke's errors, by the disciples of Hartley, of Law, of Priestley, of Tooke, and of Darwin.[2]

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[1] The name of Hobbes occurs in Mr Locke's *Reply to the Bishop of Worcester*. See the Notes on his Essay, B. iv. c. 3. It is curious that he classes Hobbes and Spinoza together, as writers of the same stamp; and that he disclaims any intimate acquaintance with the works of either. "I am not so well read in *Hobbes* and *Spinoza* as to be able to say what were their opinions in this matter, but possibly there be those who will think your Lordship's authority of more use than those justly decried names," &c. &c.

[2] See Shaftesbury's First Letter to a Student at the University.

To a person who now reads with attention and candour the work in question, it is much more easy to enter into the prejudices which at first opposed themselves to its complete success, than to conceive how it should so soon have acquired its just celebrity. Something, I suspect, must be ascribed to the political importance which Mr Locke had previously acquired as the champion of religious toleration; as the great apostle of the Revolution; and as the intrepid opposer of a tyranny which had been recently overthrown.

In Scotland, where the liberal constitution of the universities has been always peculiarly favourable to the diffusion of a free and eclectic spirit of inquiry, the philosophy of Locke seems very early to have struck its roots, deeply and permanently, into a kindly and congenial soil. Nor were the errors of this great man implicitly adopted from a blind reverence for his name. The works of Descartes still continued to be studied and admired; and the combined systems of the English and the French metaphysicians served, in many respects, to correct what was faulty, and to supply what was deficient, in each. As to the *ethical* principles of Locke, where they appear to lean towards Hobbism, a powerful antidote against them was already prepared in the Treatise *De Jure Belli et Pacis*, which was then universally and deservedly regarded in this country as the best introduction that had yet appeared to the study of moral science. If Scotland, at this period, produced no eminent authors in these branches of learning, it was not from want of erudition or of talents; nor yet from the narrowness of mind incident to the inhabitants of remote and insulated regions; but from the almost insuperable difficulty of writing in a dialect, which imposed upon an author the double task of at once acquiring a new language, and of unlearning his own.[3]

The success of Locke's Essay, in some parts of the Continent, was equally remarkable; owing, no doubt, in the first instance, to the very accurate translation of it into the French language by Coste, and to the eagerness with which every thing proceeding from the author of the *Letters on Toleration*[4] may be presumed to

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[1] "It was proposed at a meeting of the heads of houses of the University of Oxford, to censure and discourage the reading of Locke's Essay; and, after various debates among themselves, it was concluded, that each head of a house should endeavour to prevent its being read in his college, without coming to any public censure."—(See Des Maizeaux's note on a letter from Locke to Collins.—LOCKE's *Works*, Vol. X. p. 284.

[2] I have taken notice, with due praise, in the former part of this discourse, of the metaphysical speculations of John Smith, Henry More, and Ralph Cudworth; all of them members and ornaments of the University of Cambridge about the middle of the seventeeth century. They were deeply conversant in the Platonic Philosophy, and applied it with great success in combating the Materialists and Necessitarians of their times. They carried, indeed, some of their Platonic notions to an excess bordering on mysticism, and may, perhaps, have contributed to give a bias to some of their academical successors towards the opposite extreme. A very pleasing and interesting account of the characters of these amiable and ingenious men, and of the spirit of their philosophy, is given by Burnet in the *History of his Own Times.*

To the credit of Smith and of More it may be added, that they were among the first in England to perceive and to acknowledge the merits of the Cartesian Metaphysics.

[3] Note S.

[4] The principle of religious toleration was at that time very imperfectly admitted, even by those philosophers who were the most zealously attached to the cause of civil liberty. The great Scottish lawyer and statesman, Lord Stair, himself no mean philosopher, and, like Locke, a warm partizan of the Revolution, seems evidently to have regretted the impunity which Spinoza had experienced in Holland, and Hobbes in England. "Execrabilis ille Atheus Spinosa adeo impudens est, ut affirmet omnia esse absolute necessaria, et nihil quod est, fuit, aut erit, aliter fieri potuisse, in quo omnes superiores Atheos excessit, aperte negans omnem Deitatem, nihilque præter potentias naturæ agnoscens.

"Vaninus Deitatem non aperte negavit, sed causam illius prodidit, in tractatu quem edidit, argumenta pro Dei existentia tanquam futilia et vana rejiciens, adferendo contrarias omnes rationes per modum objectionum, easque prosequendo ut

have been read by the multitude of learned and enlightened refugees, whom the revocation of the edict of Nantz forced to seek an asylum in Protestant countries. In Holland, where Locke was personally known to the most distinguished characters, both literary and political, his work was read and praised by a discerning few, with all the partiality of friendship;[1] but it does not seem to have made its way into the schools till a period considerably later. The doctrines of Descartes, at first so vehemently opposed in that country, were now so completely triumphant, both among philosophers and divines,[2] that it was difficult for a new reformer to obtain a hearing. The case was very nearly similar in Germany, where Leibnitz (who always speaks coldly of Locke's Essay)[3] was then looked up to as the great oracle in every branch of learning and of science. If I am not mistaken, it was in Switzerland, where (as Gibbon observes) "the intermixture of sects had rendered the clergy acute and learned on controversial topics," that Locke's real merits were first appreciated on the Continent with a discriminating impartiality. In Crousaz's Treatise of Logic (a book which, if not distinguished by originality of genius, is at least strongly marked with the sound and unprejudiced judgment of the author), we everywhere trace the influence of Locke's doctrines; and, at the same time, the effects of the Cartesian Metaphysics, in limiting those hasty expressions of Locke, which have been so often misinterpreted by his followers.[4] Nor do Crousaz's academical labours appear to have been less

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indissolubiles videantur; postea tamen larvam exuit, et atheismum clare professus est, ET JUSTISSIME IN INCLYTA URBE THOLOSA DAMNATUS EST ET CREMATUS.

"Horrendus Hobbesius tertius erat atheismi promotor, qui omnia principia moralia et politica subvertit, eorumque loco naturalem vim et humana pacta, ut prima principia moralitatis, societatis, et politici regiminis substituit: NEC TAMEN SPINOSA AUT HOBBIUS, QUAMVIS IN REGIONIBUS REFORMATIS VIXERINT ET MORTUI SINT, NEDUM EXEMPLA FACTI SUNT IN ATHEORUM TERROREM, UT NE VEL ULLAM PÆNAM SENSERINT."—(*Physiol. Nova Experimentalis.* Lugd. Batav. 1666, pp. 16, 17.)

[1] Among those whose society Locke chiefly cultivated while in Holland, was the celebrated Le Clerc, the author of the *Bibliothèque Universelle*, and the *Bibliothèque Choisie*, besides many other learned and ingenious publications. He appears to have been warmly attached to Locke, and embraced the fundamental doctrines of his Essay without any slavish deference for his authority. Though he fixed his residence at Amsterdam, where he taught Philosophy and the Belles Lettres, he was a native of Geneva, where he also received his academical education. He is, therefore, to be numbered with Locke's *Swiss* disciples. I shall have occasion to speak of him more at length afterwards, when I come to mention his controversy with Bayle. At present, I shall only observe, that his Eloge on Locke was published in the *Bibliothèque Choisie* (Année 1705,) Tom. VI.; and that some important remarks on the *Essay on Human Understanding*, particularly on the chapter on Power, are to be found in the 12th Vol. of the same work (Année 1707.)

[2] Quamvis huic sectæ (Cartesianæ) initio acriter se opponerent Theologi et Philosophi Belgæ, in Academiis tamen eorum *hodie* (1727,) vix alia, quam Cartesiana principia inculcantur.—(HEINECCII *Elem. Hist. Philosoph.*) In Gravesande's *Introductio ad Philosophiam*, published in 1736, the name of Locke is not once mentioned. It is probable that this last author was partly influenced by his admiration for Leibnitz, whom he servilely followed even in his *physical* errors.

[3] In Lockio sunt quædam particularia non male exposita, sed in summa longe aberravit a janua, nec naturam mentis veritatisque intellexit.—(LEIBNITZ. *Op.* Tom. V. p. 355. ed. Dutens.)

M. Locke avoit de la subtilité et de l'addresse, et quelque espèce de métaphysique superficielle qu'il savoit relever.—(*Ibid.* pp. 11, 12.)

Heineccius, a native of Saxony, in a Sketch of the History of Philosophy, printed in 1728, omits altogether the name of Locke in his enumeration of the logical and metaphysical writers of modern Europe. In a passage of his logic, where the same author treats of *clear* and *obscure*, *adequate* and *inadequate ideas* (a subject on which little or nothing of any value had been advanced before Locke), he observes, in a note, "Debemus hanc Doctrinam Leibnitio, eamque deinde sequutus est illust. Wolfius."

[4] Of the *Essay on Human Understanding* Crousaz speaks in the following terms: "Clarissimi, et merito celebratissimi Lockii de Intellectu Humano eximium opus, et auctore suo dignissimum, *logicis* utilissimis semper annumerabitur."—(*Præfat.*) If Pope had ever looked into this Treatise, he could not have committed so gross a mistake, as to introduce the author into the Dunciad, among Locke's Aristotelian opponents; a distinction for which Crousaz was probably indebted to his acute strictures on those passages in *the Essay on Man*, which seem favourable to fatalism.

> Prompt at the call, around the goddess roll
> Broad hats, and hoods, and caps, a sable shoal;
> Thick and more thick the black blockade extends,
> A hundred head of Aristotle's friends.
> Nor wert thou, Isis! wanting to the day
> (Though Christ-church long kept prudishly away).
> Each staunch Polemic, stubborn as a rock,
> Each fierce Logician, still expelling Locke,
> Came whip and spur, and dash'd through thin and thick
> On German Crousaz, and Dutch Burgersdyck.

Warburton, with his usual scurrility towards all Pope's adversaries as well as his own, has called Crousaz *a blundering Swiss*; but a very different estimate of his merits has been formed by Gibbon, who seems to have studied his works much more carefully than the Right Reverend Commentator on the Dunciad.

"M. de Crousaz, the adversary of Bayle and Pope, is not distinguished by lively fancy or profound reflection; and useful than his writings; if a judgment on this point may be formed from the sound philosophical principles which he diffused among a numerous race of pupils. One of these (M. Allamand), the friend and correspondent of Gibbon, deserves particularly to be noticed here, on account of two letters published in the posthumous works of that historian, containing a criticism on Locke's argument against innate ideas, so very able and judicious, that it may still be read with advantage by many logicians of no small note in the learned world. Had these letters happened to have sooner attracted my attention, I should not have delayed so long to do this tardy justice to their merits.[1]

I am not able to speak with confidence of the period at which Locke's Essay began to attract public notice in France. Voltaire, in a letter to Horace Walpole, asserts, that he was the first person who made the name of Locke known to his countrymen;[2] but I suspect that this assertion must be received with considerable qualifications. The striking coincidence between some of Locke's most celebrated doctrines and those of Gassendi, can scarcely be supposed to have been altogether overlooked by the followers and admirers of the latter; considering the immediate and very general circulation given on the Continent to the *Essay on Human Understanding*, by Coste's French version. The *Gassendists*, too, it must be remembered, formed, even before the death of their master, a party formidable in talents as well as in numbers; including, among other distinguished names, those of Molière,[3]

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even in his own country, at the end of a few years, his name and writings are almost obliterated. But his Philosophy had been formed in the school of Locke, his Divinity in that of Limborch and Le Clerc; in a long and laborious life, several generations of pupils were taught to think, and even to write; his lessons rescued the Academy of Lausanne from Calvinistic prejudices; and he had the rare merit of diffusing a more liberal spirit among the people of the *Pays de Vaud*."—(GIBBON'S *Memoirs.*)

In a subsequent passage Gibbon says, "the logic of Crousaz had prepared me to engage with his master Locke, and his antagonist Bayle; of whom the former may be used as a bridle, and the latter applied as a spur to the curiosity of a young philosopher."—*(Ibid.)*

The following details, independently of their reference to Crousaz, are so interesting in themselves, and afford so strong a testimony to the utility of logical studies, when rationally conducted, that I am tempted to transcribe them.

"December 1755. In finishing this year, I must remark how favourable it was to my studies. In the space of eight months, I learned the principles of drawing; made myself completely master of the French and Latin languages, with which I was very superficially acquainted before, and wrote and translated a great deal in both; read Cicero's Epistles ad Familiares, his Brutus, all his Orations, his Dialogues de Amicitia et de Senectute; Terence twice, and Pliny's Epistles. In French, Giannoni's History of Naples, l'Abbé Banier's Mythology, and M. Roehat's Memoires sur la Suisse, and wrote a very ample relation of my tour. I likewise began to study Greek, and went through the grammar. I began to make very large collections of what I read. But what I esteem most of all,—from the perusal and meditation of De Crousaz's logic, I not only understood the principles of that science, but formed my mind to a habit of thinking and reasoning, I had no idea of before."

After all, I very readily grant, that Crousaz's logic is chiefly to be regarded as the work of a sagacious and enlightened compiler; but even this (due allowance being made for the state of philosophy when it appeared) is no mean praise. "Good sense (as Gibbon has very truly observed) is a quality of mind hardly less rare than genius."

[1] For some remarks of M. Allamand, which approach very near to Reid's Objections to the Ideal Theory, See Note T.

Of this extraordinary man Gibbon gives the following account in his *Journal;* "C'est un ministre dans le Pays de Vaud, et un des plus beaux génies que je connoisse. Il a voulu embrasser tous les genres; mais c'est la Philosophie qu'il a le plus approfondi. Sur toutes les questions il s'est fait des systêmes, ou du moins des argumens toujours originaux et toujours ingénieux. Ses idées sont fines et lumineuses, son expression heureuse et facile. On lui reproche avec raison trop de rafinement et de subtilité dans l'esprit; trop de fierté, trop d'ambition, et trop de violence dans le caractère. Cet homme, qui auroit pu éclairer ou troubler une nation, vit et mourra dans l'obscurité."

It is of the same person that Gibbon sneeringly says, in the words of Vossius, "*Est sacrificulus in pago, et rusticos decipit.*"

[2] "Je peux vous assurer qu'avant moi personne en France ne connoissoit la poesie Angloise; à peine avoit on entendu parler de Locke. J'ai été persecuté pendant trente ans par une nuée de fanatiques pour avoir dit que Locke est l'Hercule de la Métaphysique, qui a posé les bornes de l'Esprit Humain."—(Ferney, 1768.)

In the following passage of *the Age of Louis XIV.* the same celebrated writer is so lavish and undistinguishing in his praise of Locke, as almost to justify a doubt whether he had ever read the book which he extols so highly. "Locke seul a développé *l'entendement humain*, dans un livre où il n'y a que des vérités; et ce qui rend l'ouvrage parfait, toutes ces vérités sont claires."

[3] Molière was in his youth so strongly attached to the Epicurean theories, that he had projected a translation of Lucretius into French. He is even said to have made some progress in executing his design, when a trifling accident determined him, in a moment of ill humour, to throw his manuscript into the fire. The plan on which he was to proceed in this bold undertaking does honour to his good sense and good taste, and seems to me the only one on which a successful version of Lucretius can ever be executed. The didactic passages of the poem were to be translated into prose, and the descriptive passages into verse. Both parts would have gained greatly by this compromise; for, where Lucretius wishes to unfold the philosophy of his master, he is not less admirable for the perspicuity and precision of his expressions, than he is on other occasions, where his object is to detain and delight the imaginations of his readers, for the charms of his figurative diction, and for the bold relief of his images. In instances of the former kind, no modern language can give

Chapelle,[1] and Bernier;[2] all of them eminently calculated to give the tone, on disputed questions of Metaphysics, to that numerous class of Parisians of both sexes, with whom the practical lessons, vulgarly imputed to Epicurus, were not likely to operate to the prejudice of his speculative principles. Of the three persons just mentioned, the two last died only a few years before Locke's *Essay* was published; and may be presumed to have left behind them many younger pupils of the same school. One thing is certain, that, long before the middle of the last century, the *Essay on Human Understanding* was not only read by the learned, but had made its way into the circles of fashion at Paris.[3] In what manner this is to be accounted for, it is not easy to say; but the fact will not be disputed by those who are at all acquainted with the history of French literature.

In consequence of this rapid and extensive circulation of the work in question, and the strong impression that it everywhere produced, by the new and striking contrast which it exhibited to the doctrines of the schools, a very remarkable change soon manifested itself in the prevailing habits of thinking on philosophical subjects. Not that it is to be supposed that the opinions of men, on particular articles of their former creed, underwent a sudden alteration. I speak only of the *general effect* of Locke's discussions, in preparing the thinking part of his readers, to a degree till then unknown, for the unshackled use of their own reason. This has always appeared to me the most characteristical feature of Locke's Essay; and *that* to which it is chiefly indebted for its immense influence on the philosophy of the eighteenth century. Few books can be named, from which it is possible to extract more exceptionable passages; but, such is the liberal tone of the author; such the manliness with which he constantly appeals to *reason*, as the paramount authority which, even in religious controversy, every candid disputant is bound to acknowledge; and such the sincerity and simplicity with which, on all occasions, he appears to inquire after truth, that the *general effect* of the whole work may be regarded as the best of all antidotes against the errors involved in some of its particular conclusions.[4]

To attempt any general review of the doctrines

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even the *semblance* of poetry to the theories of Epicurus; while, at the same time, in the vain attempt to conquer this difficulty, the rigorous precision and simplicity of the original are inevitably lost.

The influence of Gassendi's instructions may be traced in several of Molière's comedies; particularly in the *Femmes Savantes*, and in a little piece *Le Mariage Forcé*, where an Aristotelian and a Cartesian doctor are both held up to the same sort of ridicule, which, in some other of his performances, he has so lavishly bestowed on the medical professors of his time.

[1] The joint author, with Bachaumont, of the *Voyage en Provence*, which is still regarded as the most perfect model of that light, easy, and graceful *badinage* which seems to belong exclusively to French poetry. Gassendi, who was an intimate friend of his father, was so charmed with his vivacity while a boy, that he condescended to be his instructor in philosophy; admitting, at the same time, to his lessons, two other illustrious pupils, Molière and Bernier. The life of Chapelle, according to all his biographers, exhibited a complete contrast to the simple and ascetic manners of his master; but, if the following account is to be credited, he missed no opportunity of propagating, as widely as he could, the speculative principles in which he had been educated. "Il étoit fort éloquent dans l'ivresse. Il restoit ordinairement le dernier à table, et se mettoit à expliquer aux valets la philosophie d'Epicure."—(*Biographie Universelle*, article *Chapelle*, Paris, 1813.) He died in 1686.

[2] The well known author of one of our most interesting and instructive books of travels. After his return from the East, where he resided twelve years at the court of the Great Mogul, he published at Lyons, an excellent *Abridgment of the Philosophy of Gassendi*, in 8 vols. 12mo; a second edition of which, corrected by himself, afterwards appeared, in seven volumes. To this second edition (which I have never met with) is annexed a Supplement, entitled *Doutes de M. Bernier sur quelques uns des principaux Chapitres de son Abregé de la Philosophie de Gassendi*. It is to this work, I presume, that Leibnitz alludes in the following passage of a letter to John Bernouilli; and, from the manner in which he speaks of its contents, it would seem to be an object of some curiosity. "Frustra quæsivi apud typographos librum cui titulus; *Doutes de M. Bernier sur la Philosophie*, in Gallia ante annos aliquot editum et mihi visum, sed nunc non repertum. Vellem autem ideo iterum legere, quia ille *Gassendistorum* fuit Princeps; sed paullo ante mortem, libello hoc edito ingenue professus est, in quibus nec Gassendus nec Cartesius satisfaciant."—(LEIBNITII et JO. BERNOUILLI *Commerc. Epist.* 2 vol. 4to. Laussanæ et Genevæ, 1745.)

Bernier died in 1688.

[3] A decisive proof of this is afforded by the allusions to Locke's doctrines in the dramatic pieces then in possession of the French stage. See Note U.

[4] The maxim which he constantly inculcates is, that "Reason must be our last judge and guide in every thing."—(LOCKE's *Works*, Vol. III. p. 145.) To the same purpose, he elsewhere observes, that "he who makes use of the light and faculties God has given him, and seeks sincerely to discover truth by those helps and abilities he has, may have this satisfaction in doing his duty as a rational creature; that, though he should miss truth, he will not miss the reward of it. For *he* governs his assent right, and places it as he should, who in any case or matter whatsoever, believes or disbelieves, according as reason directs him. He that does otherwise, transgresses against his own light, and misuses those faculties which were given him to no other end, but to search and follow the clearer evidence and greater probability."—(*Ibid.* p. 125.)

sanctioned, or supposed to be sanctioned, by the name of Locke, would be obviously incompatible with the design of this Discourse; but, among these doctrines, there are *two*, of fundamental importance, which have misled so many of his successors, that a few remarks on each form a necessary preparation for some historical details which will afterwards occur. The first of these doctrines relates to the ORIGIN OF OUR IDEAS; the second to THE POWER OF MORAL PERCEPTION, AND THE IMMUTABILITY OF MORAL DISTINCTIONS. On *both* questions, the real opinion of Locke has, if I am not widely mistaken, been very grossly misapprehended or misrepresented, by a large portion of his professed followers, as well as of his avowed antagonists.

1. The objections to which Locke's doctrine concerning the origin of our ideas, or, in other words, concerning the sources of our knowledge, are, in my judgment, liable, I have stated so fully in a former work,[1] that I shall not touch on them here. It is quite sufficient, on the present occasion, to remark, how very unjustly *this* doctrine (imperfect, on the most favourable construction, as it undoubtedly is) has been confounded with those of Gassendi, of Condillac, of Diderot, and of Horne Tooke. The substance of all that is common in the conclusions of these last writers, cannot be better expressed than in the words of their Master, Gassendi. "All our knowledge (he observes in a letter to Descartes) appears plainly to derive its origin from the senses; and although you deny the maxim, 'Quicquid est in intellectu præesse debere in sensu,' yet this maxim appears, nevertheless, to be true; since our knowledge is all ultimately obtained by an *influx* or *incursion* from things external; which knowledge afterwards undergoes various modifications by means of analogy, composition, division, amplification, extenuation, and other similar processes, which it is unnecessary to enumerate."[2]

This doctrine of Gassendi's coincides exactly with that ascribed to Locke by Diderot and by Horne Tooke; and it differs only verbally from the more concise statement of Condillac, that "our ideas are nothing more than *transformed* sensations." "Every idea," says the first of these writers, "must necessarily, when brought to its state of ultimate decomposition, resolve itself into a *sensible* representation or picture; and since every thing *in* our understanding has been introduced there by the channel of sensation, whatever proceeds *out* of the understanding is either chimerical, or must be able, in returning by the same road, to re-attach itself to its sensible archetype. Hence an important rule in philosophy,—that every expression which cannot find an external and a sensible object, to which

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[1] *Philosophical Essays.*

[2] "Deinde omnis nostra notitia videtur plane ducere originem a sensibus; et quamvis tu neges quicquid est in intellectu præesse debere in sensu, videtur id esse nihilominus verum, cum nisi sola incursione κατὰ περίπτωσιν, ut loquuntur, fiat; perficiatur tamen analogia, compositione, divisione, ampliatione, extenuatione, aliisque similibus modis, quos commemorare nihil est necesse."—*(Objectiones in Meditationem Secundam.)*

This doctrine of Gassendi's is thus very clearly stated and illustrated, by the judicious authors of the *Port Royal Logic:* "Un philosophe qui est estimé dans le monde commence sa logique par cette proposition: *Omnis idea orsum ducit a sensibus. Toute idée tire son origine des sens.* Il avoue néanmoins que toutes nos idées n'ont pas été dans nos sens telles qu'elles sont dans notre esprit: mais il prétend qu'elles ont au moins été formées de celles qui ont passé par nos sens, ou par *composition*, comme lorsque des images separées de l'or et d'une montagne, on s'en fait une montagne d'or; ou par *ampliation* et *diminution*, comme lorsque de l'image d'un homme d'une grandeur ordinaire on s'en forme un géant ou un pigmée; ou par *accommodation* et *proportion*, comme lorsque de l'idée d'une maison qu'on a vue, on s'en forme l'image d'une maison qu'on n'a pas vue. ET AINSI, dit il, NOUS CONCEVONS DIEU QUI NE PEUT TOMBER SOUS LES SENS, SOUS L'IMAGE D'UN VENERABLE VIEILLARD." "Selon cette pensée, quoique toutes nos idées ne fussent semblables à quelque corps particulier que nous ayons vu, ou qui ait frappé nos sens, elles seroient néanmoins toutes corporelles, et ne vous representeroient rien qui ne fût entré dans nos sens, au moins par parties. Et ainsi nous ne concevons rien que par des images, semblables à celles qui se forment dans les cerveau quand nous voyons, ou nous nous imaginons des corps."—(*L'Art de Penser*, I Partie. c. 1.)

The reference made, in the foregoing quotation, to Gassendi's illustration drawn from *the idea of God*, affords me an opportunity, of which I gladly avail myself, to contrast it with Locke's opinion on the same subject. "How many amongst us will be found, upon inquiry, to fancy God, in the shape of a man, sitting in heaven, and to have many other absurd and unfit conceptions of him? Christians, as well as Turks, have had whole sects owning, or contending earnestly for it, that the Deity was corporeal and of human shape: And although we find few amongst us, who profess themselves *Anthropomorphites* (though some I have met with that own it), yet, I believe, he that will make it his business, may find amongst the ignorant and uninstructed Christians, many of that opinion."*—(Vol. I. p. 67.)

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* In the judgment of a very learned and pious divine, the bias towards *Anthropomorphism*, which Mr Locke has here so severely reprehended, is not confined to "ignorant and uninstructed Christians." "If *Anthropomorphism* (says Dr Maclaine) was banished from theology, orthodoxy would be deprived of some of its most precious phrases, and our confessions of faith

it can thus establish its affinity, is destitute of signification."—(*Oeuvres de* Diderot, Tom. VI.)

Such is the exposition given by Diderot, of what is regarded in France as Locke's great and capital *discovery;* and precisely to the same purpose we are told by Condorcet, that " Locke was the first who proved that *all our ideas are compounded of sensations.*"—(*Esquisse Historique*, &c.)

If this were to be admitted as a fair account of Locke's opinion, it would follow, that he has not advanced a single step beyond Gassendi and Hobbes; both of whom have repeatedly expressed themselves in nearly the same words with Diderot and Condorcet. But although it must be granted, in favour of their interpretation of his language, that various detached passages may be quoted from his work, which seem, on a superficial view, to justify their comments, yet of what weight, it may be asked, are these passages, when compared with the stress laid by the author on *Reflection*, as an original source of our ideas, altogether different from *Sensation?* " The *other fountain*," says Locke, " from which experience furnisheth the understanding with ideas, is the perception of the operations of our own minds within us, as it is employed about the ideas it has got; which operations, when the soul comes to *reflect on* and consider, do furnish the understanding with another set of ideas, which could not be had from things without; and such are *Perception*, *Thinking*, *Doubting*, *Be-*

" Let the ideas of being and matter be strongly joined either by education or much thought, whilst these are still combined in the mind, what notions, what reasonings will there be about separate spirits? Let custom, from the very childhood, have joined figure and shape to the idea of God, and what absurdities will that mind be liable to about the Deity?"—(Vol. II. p. 144.)

The authors of the *Port Royal Logic* have expressed themselves on this point to the very same purpose with Locke; and have enlarged upon it still more fully and forcibly. (See the sequel of the passage above quoted.) Some of their remarks on the subject, which are more particularly directed against Gassendi, have led Brucker to rank them among the advocates for *innate ideas* (BRUCKER, *Historia de Ideis*, p. 271), although these remarks coincide exactly in substance with the foregoing quotation from Locke. Like many other modern metaphysicians, this learned and laborious, but not very acute historian, could imagine no intermediate opinion between the theory of *innate ideas*, as taught by the Cartesians, and the Epicurean account of our knowledge, as revived by Gassendi and Hobbes; and accordingly thought himself entitled to conclude, that whoever rejected the one must necessarily have adopted the other. The doctrines of Locke and of his predecessor Arnauld will be found, on examination, essentially different from both.

Persons little acquainted with the metaphysical speculations of the two last centuries are apt to imagine, that when " all knowledge is said to have its origin in the senses," nothing more is to be understood than this, that it is by the impressions of external objects on our organs of perception, that *the dormant powers* of the understanding are at first awakened. The foregoing quotation from Gassendi, together with those which I am about to produce from Diderot and Condorcet, may, I trust, be useful in correcting this very common mistake; all of these quotations explicitly asserting, that the external senses furnish not only the *occasions* by which our intellectual powers are excited and developed, but all the *materials* about which our thoughts are conversant; or, in other words, that it is impossible for us to think of anything, which is not either a sensible image, or the result of sensible images combined together, and transmuted into new forms by a sort of logical chemistry. That the powers of the understanding would for ever continue dormant, were it not for the action of things external on the bodily frame, is a proposition now universally admitted by philosophers. Even Mr Harris and Lord Monboddo, the two most zealous, as well as most learned of Mr Locke's adversaries in England, have, in the most explicit manner, expressed their assent to the common doctrine. " The first class of ideas (says Monboddo) is produced from ideas furnished by the senses; the second arises from the operations of the mind upon these materials: for I do not deny, that in this our present state of existence, all our ideas, and all our knowledge, are ultimately to be derived from sense and matter." (Vol. I. p. 44. 2d Ed.) Mr Harris, while he holds the same language, points out, with greater precision, the essential difference between his philosophy and that of the Hobbists. " Though sensible objects may be the destined medium to awaken the dormant energies of man's understanding, yet are those energies themselves no more contained in sense, than the explosion of a cannon in the spark which gave it fire."—(HERMES.) On this subject see *Elements of the Philosophy of the Human Mind*, Vol. I. chap. i. sect. 4.

To this doctrine I have little doubt that Descartes himself would have assented, although the contrary opinion has been generally supposed by his adversaries to be virtually involved in his *Theory of Innate Ideas.* My reasons for thinking so, the reader will find stated in Note X.

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and systems of doctrine would be reduced within much narrower bounds."—(Note on Mosheim's *Church History*, Vol. IV. p. 550.)

On this point I do not presume to offer any opinion; but one thing I consider as indisputable, that it is by means of *Anthropomorphism*, and other idolatrous pictures of the invisible world, that superstition lays hold of the infant mind. Such pictures operate not upon Reason, but upon the Imagination; producing that temporary belief with which I conceive all the illusions of imagination to be accompanied.

In point of fact, the bias of which Locke speaks extends in a greater or less degree to all men of strong imaginations, whose education has not been very carefully superintended in early infancy.

I have applied to *Anthropomorphism* the epithet idolatrous, as it seems to be essentially the same thing to bow down and worship a graven image of the Supreme Being, and to worship a supposed likeness of Him conceived by the Imagination.

In Bernier's *Abridgment of Gassendi's Philosophy* (Tom. III. p. 13 *et seq.*) an attempt is made to reconcile with the Epicurean account of the origin of our knowledge, that more pure and exalted idea of God to which the mind is gradually led by the exercise of its reasoning powers: But I am very doubtful, if Gassendi would have subscribed, in this instance, to the comments of his ingenious disciple.

lieving, *Reasoning*, *Knowing*, *Willing*, and all the different actings of our own minds, which, we being conscious of, and observing in ourselves, do from these receive into our understandings ideas as distinct as we do from bodies affecting our senses. This source of ideas every man has wholly in himself: And though it be not sense, *as having nothing to do with external objects*, yet it is very like it, and might properly enough be called *internal sense.* But as I call the other SENSATION, so I call this REFLECTION; the ideas it affords being such only as the mind gets by *reflecting* on its own operations within itself."[1] —(LOCKE's *Works*, Vol. I. p. 78.)

"The understanding seems to me not to have the least glimmering of any ideas which it doth not receive from one of these two. *External objects furnish the mind with the ideas of sensible qualities; and the mind furnishes the understanding with ideas of its own operations.*"—(*Ibid.* p. 79.)

In another part of the same chapter, Locke expresses himself thus: "Men come to be furnished with fewer or more simple ideas from without, according as the objects they converse with afford greater or less variety; and from the operations of their minds within, according as they more or less REFLECT on them. For, though he that contemplates the operations of his mind, cannot but have plain and clear ideas of them; yet, unless he turn his thoughts that way, and consider them *attentively*, he will no more have clear and distinct ideas of all the operations of his mind, and all that may be observed therein, than he will have all the particular ideas of any landscape, or of the parts and motions of a clock, who will not turn his eyes to it, and with attention heed all the parts of it. The picture, or clock, may be so placed, that they may come in his way every day; but yet he will have but a confused idea of all the parts they are made up of, till he applies himself with attention to consider them in each particular.

"And hence we see the reason why it is pretty late before most children get ideas of the operations of their own minds; and some have not any very clear or perfect ideas of the greatest part of them all their lives. . . . . Children, when they first come into it, are surrounded with a world of new things, which, by a constant solicitation of their senses, draw the mind constantly to them,—forward to take notice of new, and apt to be delighted with the variety of changing objects. Thus, the first years are usually employed and directed in looking abroad. Men's business in them is to acquaint themselves with what is to be found without; and so growing up in a constant attention to outward sensations, seldom make any considerable reflection on what passes within them, till they come to be of riper years; and some scarce ever at all."—(*Ibid.* pp. 80. 81.)

I beg leave to request more particularly the attention of my readers to the following paragraphs:

"If it be demanded, *when a man begins to have any ideas?* I think the true answer is, when he first has any *sensation.* . . . . I conceive that ideas in the understanding are coëval with *sensation;* which is such an impression or motion, made in some part of the body, as produces some perception in the understanding. It is about these impressions made on our senses by outward objects, that the mind seems *first* to employ itself in such operations as we call *Perception*, *Remembering*, *Consideration*, *Reasoning*, &c.

"In time, the mind comes to reflect on its own operations, and about the ideas got by sensation, and thereby stores itself with a new set of ideas, which I call *ideas of reflection.* These impressions that are made on our senses by objects extrinsical to the mind; and *its own operations, proceeding from powers intrinsical and proper to itself* (which, when reflected on by itself, become also objects of its contemplation), are, as I have said, *the original of all knowledge.*"[2]—(*Ibid.* pp. 91. 92.)

A few other scattered sentences, collected from different parts of Locke's *Essay*, may throw additional light on the point in question.

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[1] Note Y.

[2] The idea attached by Locke in the above passages to the word *Reflection* is clear and precise. But in the course of his subsequent speculations, he does not always rigidly adhere to it, frequently employing it in that more extensive and popular sense in which it denotes the attentive and deliberate consideration of any object of thought, whether relating to the ex-

"I know that people, whose thoughts are immersed in matter, and have so subjected their minds to their senses, that they seldom reflect on anything beyond them, are apt to say, they cannot comprehend a *thinking* thing, which perhaps is true: But I affirm, when they consider it well, they can no more comprehend an *extended* thing.

"If any one say, he knows not what 'tis thinks in him; he means he knows not what the substance is of that thinking thing: No more, say I, knows he what the substance is of that solid thing. Farther, if he says, he knows not *how* he thinks; I answer, Neither knows he *how* he is extended; *how* the solid parts of body are united, or cohere together to make extension." —(Vol. II. p. 22.)

"I think we have as many and as clear ideas belonging to mind, as we have belonging to body, the substance of each being equally unknown to us; and the idea of thinking in mind as clear as of extension in body; and the communication of motion by thought which we attribute to mind, is as evident as that by impulse, which we ascribe to body. Constant experience makes us sensible of both of these, though our narrow understanding can comprehend neither.[1]

"To conclude; Sensation convinces us, that there are solid extended substances; and Reflection, that there are thinking ones: Experience assures us of the existence of such beings; and that the one hath a power to move body by impulse, the other by thought; *this* we cannot doubt of. But beyond these ideas, as received from their proper sources, our faculties will not reach. If we would inquire farther into their nature, causes, and manner, we perceive not the nature of Extension clearer than we do of Thinking. If we would explain them any farther, one is as easy as the other; and there is no more difficulty to conceive *how* a substance we know not should by *thought* set body into motion, than how a substance we know not should, by *impulse*, set body into motion."—(*Ibid.* pp. 26. 27.)

The passage in Locke which, on a superficial view, appears the most favourable to the misinterpretation put on his account of the Sources of our Knowledge, by so many of his professed followers, is, in my opinion, the following:

"It may also lead us a little towards the original of all our notions and knowledge, if we remark, how great a dependence our words have on common sensible ideas; and how those which are made use of to stand for actions and notions quite removed from sense, have their rise from thence, and from obvious sensible ideas are transferred to more abstruse significations, and made to stand for ideas that come not under the cognizance of our senses; *v. g.* to *imagine*, *apprehend*, *comprehend*, *adhere*, *conceive*, *instil*, *disgust*,

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ternal or to the internal world. It is in this sense he uses it when he refers to Reflection our ideas of Cause and Effect, of Identity and Diversity, and of *all other relations.* "All of these (he observes) *terminate in*, and are *concerned about*, those simple ideas, either of Sensation or Reflection, which I think to be the whole materials of all our knowledge."—(Book II. c. xxv. sect. 9.) From this explanation it would appear that Locke conceived it sufficient to justify his account of the origin of our knowledge, if it could be shown that all our ideas *terminate in, and are concerned about*, ideas derived either from Sensation or Reflection, according to which comment it will not be a difficult task to obviate every objection to which his fundamental principle concerning the two sources of our ideas may appear to be liable.

In this lax interpretation of a principle so completely interwoven with the whole of his philosophy, there is undoubtedly a departure from logical accuracy; and the same remark may be extended to the vague and indefinite use which he occasionally makes of the word *Reflection;* a word which expresses the peculiar and characteristical doctrine, by which his system is distinguished from that of the Gassendists and Hobbists. All this, however, serves only to prove still more clearly, how widely remote his real opinion on this subject was from that commonly ascribed to him by the French and German commentators. For my own part, I do not think, notwithstanding some casual expressions which may seem to favour the contrary supposition, that Locke would have hesitated for a moment to admit, with Cudworth and Price, that the *Understanding* is itself a source of new ideas. That it is by *Reflection* (which, according to his own definition, means merely the exercise of the *Understanding* on the internal phenomena) that we get our ideas of memory, imagination, reasoning, and of all other intellectual powers, Mr Locke has again and again told us; and from this principle it is so obvious an inference, that all the simple ideas which are necessarily implied in our intellectual operations, are ultimately to be referred to the same source, that we cannot reasonably suppose a philosopher of Locke's sagacity to admit the former proposition, and to withhold his assent to the latter.

[1] In transcribing this paragraph, I have taken the liberty to substitute the word *Mind* instead of *Spirit.* The two words were plainly considered by Locke, on the present occasion, as quite synonymous; and the latter (which *seems* to involve a theory concerning the nature of the thinking principle) is now almost universally rejected by English metaphysicians from their Philosophical Vocabulary.

disturbance, *tranquillity*, &c. are all words taken from the operations of sensible things, and applied to certain modes of thinking. *Spirit*, in its primary signification, is breath; *angel*, a messenger: *and I doubt not, but if we could trace them to their sources, we should find, in all languages, the names which stand for things that fall not under our senses, to have had their first rise from sensible ideas.* By which we may give some kind of guess what kind of notions they were, and whence derived, which filled their minds, who were the first beginners of languages; and how nature, even in the naming of things, unawares suggested to men the originals and principles of all their knowledge."

So far the words of Locke coincide very nearly, if not exactly, with the doctrines of Hobbes and of Gassendi; and I have not a doubt, that a mistaken interpretation of the clause which I have distinguished by *italics*, furnished the germ of all the mighty *discoveries* contained in the Επεα Πτεροεντα. If Mr Tooke, however, had studied with due attention the import of what immediately follows, he must have instantly perceived how essentially different Locke's real opinion on the subject was from what he conceived it to be.—"Whilst to give names, that might make known to others any operations they felt in themselves, or any other ideas that came not under their senses, they were fain to borrow words from ordinary known ideas of sensation, by that means to make others the more easily to conceive those operations they experienced in themselves, which made no outward sensible appearances; and then, when they had got known and agreed names, to signify those internal operations of their own minds, they were sufficiently furnished to make known by words all their other ideas; since they could consist of nothing but either of outward sensible perceptions, or of the inward operations of their minds about them."—(Vol. II. pp. 147, 148.)

From the sentences last quoted it is manifest, that when Locke remarked the *material* etymology of all our language about mind, he had not the most distant intention to draw from it any inference which might tend to identify the sensible images which this language presents to the fancy, with the metaphysical notions which it figuratively expresses. Through the whole of his *Essay*, he uniformly represents *sensation* and *reflection* as radically distinct sources of knowledge; and, of consequence, he must have conceived it to be not less unphilosophical to attempt an explanation of the phenomena of mind by the analogy of matter, than to think of explaining the phenomena of matter by the analogy of mind. To this fundamental principle concerning the origin of our ideas, he has added, in the passage now before us, That, as our knowledge of mind is posterior in the order of time to that of matter (the first years of our existence being necessarily occupied about objects of sense), it is not surprising, that "when men wished *to give names that might make known to others* any operations they felt in themselves, or any other ideas that came not under their senses, they should have been fain to borrow words from ordinary known ideas of sensation, by that means to make others the more easily to conceive those operations which make no outward sensible appearances." According to this statement, the purpose of these "borrowed" or metaphorical words is not (as Mr Tooke concluded) to *explain* the nature of the operations, but to direct the attention of the hearer to that internal world, the phenomena of which he can only learn to comprehend by the exercise of his own power of reflection. If Locke has nowhere affirmed so explicitly as his predecessor Descartes, that "nothing conceivable by the power of imagination can throw any light on the operations of thought," it may be presumed that he considered this as unnecessary, after having dwelt so much on *reflection* as the exclusive source of all our ideas relating to mind; and on the peculiar difficulties attending the exercise of this power, in consequence of the effect of early associations in confounding together our notions of mind and of matter.

The misapprehensions so prevalent on the Continent, with respect to Locke's doctrine on this most important of all metaphysical questions, began during his own life time, and were countenanced by the authority of no less a writer than Leibnitz, who always represents Locke as a partizan of the scholastic maxim, *Nihil est in intellectu quod non fuerit in sensu.*—" Nempe (says

Leibnitz, in reply to this maxim) nihil est in intellectu quod non fuerit in sensu, *nisi ipse intellectus.*"[1] The remark is excellent, and does honour to the acuteness of the critic; but it is not easy to conceive on what grounds it should have been urged as an objection to a writer, who

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[1] *Opera*, Tom. V. pp. 358, 359.

That the same mistake still keeps its ground among many foreign writers of the highest class, the following passage affords a sufficient proof: "Leibnitz a combattu avec une force de dialectique admirable le Systême de Locke, qui attribue toutes nos idées à nos sensations. On avoit mis en avant cet axiome si connu, qu'il n'y avoit rien dans l'intelligence qui n'eut été d'abord dans les sensations, et Leibnitz y ajouta cette sublime restriction, *si ce n'est l'intelligence elle-même.* De ce principe derive toute la philosophie nouvelle qui exerce tant d'influence sur les esprits en Allemagne."—(Mad. de Stael *de l'Allemagne*, Tom. III. p. 65.)

I observed in the First Part of this Dissertation (page 67), that this *sublime restriction* on which so much stress has been laid by the partizans of the German school, is little more than a translation of the following words of Aristotle: Καὶ αὐτὸς δὲ νοῦς νοητὸς ἐστιν, ὥσπερ τὰ νοητά· ἐπὶ μὲν γαρ τῶν ἄνευ ὕλης, τὸ αὐτὸ ἐστι τὸ νοούν καὶ τὸ νοούμενον.—(*De Anima*, Lib. III. cap. v.)

As to Locke, the same injustice which he received from Leibnitz was very early done to him in his own country. In a tract printed in 1697, by a mathematician of some note, the author of the *Essay on Human Understanding* is represented as holding the same opinion with Gassendi concerning the origin of our ideas. "*Ideæ* nomine sensu utor; earum originem an a sensibus solum, ut Gassendo et Lockio nostrati, cæterisque plurimis visum est, an aliunde, hujus loci non est inquirere."—(*De Spatio Reali, seu Ente Infinito Conamen Mathematico-Metaphysicum.* Auctore Josepho Raphson, Reg. Soc. Socio. This tract is annexed to the second edition of a work entitled *Analysis Æquationum Universalis.* Lond. 1702.)

In order to enable my readers more easily to form a judgment on the argument in the text, I must beg leave once more to remind them of the distinction already pointed out between the Gassendists and the Cartesians; the former asserting, that, as all our ideas are derived from the external senses, the intellectual phenomena can admit of no other explanation than what is furnished by analogies drawn from the material world; the latter rejecting these analogies altogether, as delusive and treacherous lights in the study of mind; and contending, that the exercise of the power of reflection is the only medium through which any knowledge of its operations is to be obtained. To the one or the other of these two classes, all the metaphysicians of the last century may be referred; and even at the present day, the fundamental question which formed the chief ground of controversy between Gassendi and Descartes (I mean the question concerning the proper logical method of studying the mind) still continues the hinge on which the most important disputes relating to the internal world will be found ultimately to turn.

According to this distinction, Locke, notwithstanding some occasional slips of his pen, belongs indisputably to the class of Cartesians; as well as the very small number of his followers who have entered thoroughly into the spirit of his philosophy. To the class of Gassendists, on the other hand, belong all those French metaphysicians, who professing to tread in Locke's footsteps, have derived all their knowledge of the *Essay on Human Understanding* from the works of Condillac; together with most of the commentators on Locke who have proceeded from the school of Bishop Law. To these may be added (among the writers of later times) Priestley, Darwin, Beddoes, and, above all, Horne Tooke with his numerous disciples.

The doctrine of Hobbes on this cardinal question coincided entirely with that of Gassendi, and, accordingly, it is not unusual in the present times, among Hobbes's disciples, to ascribe to him the whole merit of that account of the origin of our knowledge, which, from a strange misconception, has been supposed to have been claimed by Locke as his own discovery. But where, it may be asked, has Hobbes said anything about the origin of those ideas which Locke refers to the power of *reflection?* and may not the numerous observations which Locke has made on *this* power as a source of ideas peculiar to itself, be regarded as an indirect refutation of that theory which would resolve all the objects of our knowledge into *sensations*, as their ultimate elements? This was not merely a step *beyond* Hobbes; but the correction of an error which lies at the very root of Hobbes's system;—an error under which (it may be added) the greater part of Hobbes's eulogists have the misfortune still to labour.

It is with much regret I add, that a very large proportion of the English writers, who call themselves *Lockists*, and who, I have no doubt, believe themselves to be so in reality, are at bottom (at least in their metaphysical opinions) *Gassendists* or *Hobbists*. In what respect do the following observations differ from the Epicurean theory concerning the origin of our knowledge, as expounded by Gassendi? "The ideas conveyed by sight, and by our other senses, having entered the mind, intermingle, unite, separate, throw themselves into various combinations and postures, and thereby generate new ideas of reflection, strictly so called; such as those of comparing, dividing, distinguishing,—of abstraction, relation, with many others; all which remain with us as stock for our further use on future occasions." I do not recollect any passage, either in Helvetius or Diderot, which contains a more explicit and decided avowal of that Epicurean system of Metaphysics, which it was the great aim both of Descartes and of Locke to overthrow.

In the following conjectures concerning the *nature* of our ideas, the same author has far exceeded in extravagance any of the Metaphysicians of the French school. "What those *substances* are, whereof our ideas are the modifications, *whether parts of the mind as the members are of our body, or contained in it like wafers in a box, or enveloped by it like fish in water*, whether *of a spiritual, corporeal, or middle nature between both*, I need not now ascertain. All I mean to lay down at present is this, that, in every exercise of the understanding, that which discerns is *numerically and substantially distinct* from that which is discerned; and that an act of the understanding is not so much our own proper act, as the act of something else operating upon us."

I should scarcely have thought it worth while to take notice of these passages, had not the doctrines contained in the work from which they are taken, been sanctioned in the most unqualified terms by the high authority of Dr Paley. "There is one work (he observes) to which I owe so much, that it would be ungrateful not to confess the obligation: I mean the writings of the late Abraham Tucker, Esq. part of which were published by himself, and the remainder since his death, under the title of the *Light of Nature Pursued*, by Edward Search, Esq." "*I have found, in this writer, more original thinking and observation upon the several subjects that he has taken in hand, than in any other, not to say than in all others put together.* His talent also for illustration is unrivalled. But his thoughts are diffused through a long, various, and irregular work. I shall account has insisted so explicitly and so frequently on *reflection* as the source of a class of ideas essentially different from those which are derived from *sensation*. To myself it appears, that the words of Leibnitz only convey, in a more concise and epigrammatic form, the substance of Locke's doctrine. Is any thing implied in them which Locke has not more fully and clearly stated in the following sentence? "External objects furnish the mind with the ideas of sensible qualities; and the mind furnishes the understanding with ideas of its own operations." (LOCKE's *Works*, Vol. I. p. 79.)

The extraordinary zeal displayed by Locke, at the very outset of his work, against the hypothesis of *innate ideas*, goes far to account for the mistakes committed by his commentators, in interpreting his account of the origin of our knowledge. It ought, however, to be always kept in view, in reading his argument on the subject, that it is the *Cartesian* theory of innate ideas which he is here combating; according to which theory (as understood by Locke), an *innate idea* signifies *something* coeval in its existence with the mind to which it belongs, and illuminating the understanding before the external senses begin to operate. The very close affinity between this theory, and some of the doctrines of the Platonic school, prevented Leibnitz, it is probable, from judging of Locke's argument against it, with his usual candour; and disposed him hastily to conclude, that the opposition of Locke to Descartes proceeded from views essentially the same with those of Gassendi, and of his other Epicurean antagonists. How very widely he was mistaken in this conclusion, the numerous passages which I have quoted in Locke's own words sufficiently demonstrate.

In what respects Locke's account of the origin of our ideas *falls short* of the truth, will appear, when the metaphysical discussions of later times come under our review. Enough has been already said to show, how completely this account has been misapprehended, not only by his opponents, but by the most devoted of his admirers;—a misapprehension so very general, and at the same time so obviously at variance with the whole spirit of his Essay, as to prove to a demonstration that, in point of numbers, the *intelligent readers* of this celebrated work have hitherto borne but a small proportion to its purchasers and panegyrists. What an illustration of the folly of trusting, in matters of literary history, to the traditionary judgments copied by one commentator or critic from another, when recourse may so easily be had to the original sources of information![1]

II. Another misapprehension, not less prevalent than the former, with respect to Locke's philosophical creed, relates to the power of moral perception, and the immutability of moral distinctions. The consideration of such ques-

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[1] In justice to Dr Hartley, I must here observe, that, although his account of the origin of our ideas is precisely the same with that of Gassendi, Hobbes, and Condillac—one of his fundamental principles being, that the *ideas* of sensation are the *elements* of which all the rest are compounded—(HARTLEY *on Man*, 4th Ed. p. 2. of the Introduction)—he has not availed himself, like the other Gassendists of later times, of the name of Locke to recommend this theory to the favour of his readers. On the contrary, he has very clearly and candidly pointed out the wide and essential distinction between the two opinions. "It may not be amiss here to take notice how far the theory of these papers has led me to differ, in respect of logic, from Mr Locke's excellent *Essay on the Human Understanding*, to which the world is so much indebted for removing prejudices and encumbrances, and advancing real and useful knowledge.

"First, then, it appears to me, that all the most complex ideas arise from sensation, and that *reflection is not a distinct source*, as Mr Locke makes it."—(HARTLEY *on Man*, 4th Ed. p. 360 of the Introduction.)

This last proposition Hartley seems to have considered as an important and original improvement of his own on Locke's

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it no mean praise, if I have been sometimes able to dispose into method, to collect into heads and articles, or to exhibit in more compact and tangible masses, what, in that excellent performance, is spread over too much surface."—(*Principles of Moral and Political Philosophy*, Preface, pp. 25, 26.)

Of an author whom Dr Paley has honoured with so very warm an eulogy, it would be equally absurd and presumptuous to dispute the merits. Nor have I any wish to detract from the praise here bestowed on him as an original thinker and observer. I readily admit, also, his talent for illustration, although it sometimes leads him to soar into bombast, and more frequently to sink into buffoonery. As an honest inquirer after moral and religious truth, he is entitled to the most unqualified approbation. But, I must be permitted to add, that, as a metaphysician, he seems to me much more fanciful than solid; and, at the same time, to be so rambling, verbose, and excursive, as to be more likely to unsettle than to fix the principles of his readers.

tions, it may at first sight be thought, belongs rather to the history of Ethics than of Metaphysics; but it must be recollected, that, in introducing them here, I follow the example of Locke himself, who has enlarged upon them at considerable length, in his Argument against the Theory of *Innate Ideas.* An *Ethical* disquisition of this sort formed, it must be owned, an aukward introduction to a work on the Human Understanding; but the conclusion on which it is meant to bear is purely of a *Metaphysical* nature; and when combined with the premises from which it is deduced, affords a good illustration of the impossibility, in tracing the progress of these two sciences, of separating completely the history of the one from that of the other.

In what sense Locke's reasonings against *Innate Ideas* have been commonly understood, may be collected from the following passage of an author, who had certainly no wish to do injustice to Locke's opinions.

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logic; whereas, in fact, it is only a relapse into the old Epicurean hypothesis, which it was one of the main objects of Locke's Essay to explode.

I would not have enlarged so fully on Locke's account of the origin of our ideas, had not a mistaken view of his argument on this head, served as a ground-work for the whole Metaphysical Philosophy of the French *Encyclopédie.* That all our knowledge is derived from our external senses, is everywhere assumed by the conductors of that work as a demonstrated principle; and the credit of this demonstration is uniformly ascribed to Locke, who, we are told, was the first that fully unfolded and established a truth, of which his predecessors had only an imperfect glimpse. La Harpe, in his *Lycée*, has, on this account, justly censured the metaphysical phraseology of the *Encyclopédie*, as tending to degrade the intellectual nature of man; while, with a strange inconsistency, he bestows the most unqualified praise on the writings of Condillac. Little did he suspect, when he wrote the following sentences, how much the reasonings of his favourite logician had contributed to pave the way for those conclusions which he reprobates with so much asperity in Diderot and D'Alembert.

" La gloire de Condillac est d'avoir été le premier disciple de Locke; mais si Condillac eut un maître, il merita d'en servir à tous les autres; il repandit même une plus grande lumière sur les découvertes du philosophe Anglois; il les rendit pour ainsi dire sensibles, et c'est grace à lui qu'elles sont devenues communes et familières. En un mot, la saine Métaphysique ne date en France, que des ouvrages de Condillac, et à ce titre il doit être compté dans le petit nombre d'hommes qui ont avancé la science qu'ils ont cultivée."—(*Lycée*, Tome XV. pp. 136. 137.

La Harpe proceeds in the same panegyrical strain through more than seventy pages, and concludes his eulogy of Condillac with these words: " Le style de Condillac est clair et pur comme ses conceptions; c'est en general l'esprit le plus juste et le plus lumineux qui ait contribué, dans ce siècle, aux progrès de la bonne philosophie."—(*Ibid.* p. 214.)

La Harpe's account of the power of *Reflection* will form an appropriate supplement to his comments on Condillac. " L'impression sentie des objets se nomme *perception;* l'action de l'âme qui les considère, se nomme *reflexion.* Ce mot, il est vrai, exprime un mouvement physique, celui de se replier sur soi-même ou sur quelque chose; mais *toutes nos idées venant des sens*, nous sommes souvent obligés de nous servir de termes physiques pour exprimer les operations de l'âme."—(*Ibid.* p. 158.) In another passage, he defines Reflection as follows: " La faculté de reflexion, c'est-a-dire, le pouvoir qu'a notre âme, de comparer, d'assembler, de combiner les perceptions."—(*Ibid.* p. 183.) How widely do these definitions of *reflection* differ from that given by Locke; and how exactly do they accord with the Philosophy of Gassendi, of Hobbes, and of Diderot!

In a lately published sketch *Of the State of French Literature during the Eighteenth Century* (a work, to which the Author's taste and powers as a writer have attracted a degree of public attention something beyond what was due to his philosophical depth and discernment), there are some shrewd, and, in my opinion, sound remarks, on the *moral* tendency of that metaphysical system to which Condillac gave so much circulation and celebrity. I shall quote some of his strictures which bear more particularly on the foregoing argument.

" Autrefois, negligeant d'examiner tout ce mécanisme des sens, tous ces rapports directs du corps avec les objets, les philosophes ne s'occupoient que de ce qui se passe au-dedans de l'homme. La science de l'âme, telle a été la noble étude de Descartes, de Pascal, de Malebranche, de Leibnitz. (Why omit in this list the name of Locke?) . . . . . . Peut-être se perdoient-ils quelquefois dans les nuages des hautes régions où ils avoient pris leur vol; peut-être leurs travaux etoient-ils sans application directe; mais du moins ils suivoient une direction élevée, leur doctrine étoit en rapport avec les pensées qui nous agitent quand nous reflechissons profondément sur nous-mêmes. Cette route conduisoit nécessairement au plus nobles des sciences, à la religion, et à la morale. Elle supposoit dans ceux qui la cultivoient un génie élevé et de vastes meditations.

" On se lassa de les suivre; on traita de vaines subtilités, on flétrit du titre de réveries scholastiques les travaux de ces grandes esprits. On se jeta dans la science des sensations, espérant qu'elle seroit plus à la portée de l'intelligence humaine. On s'occupa de plus en plus des rapports mécaniques de l'homme avec les objets, et de l'influence de son organisation physique. De cette sorte, la métaphysique alla toujours se rabaissant, au point que maintenant, pour quelques personnes, elle se confond presque avec la physiologie. . . . Le dix-huitième siècle a voulu faire de cette manière d'envisager l'homme un de ses principaux titres de gloire. . . . .

" Condillac est le chef de cette école. C'est dans ses ouvrages que cette métaphysique exerce toutes les seductions de la méthode, et de la lucidité; d'autant plus claire, qu'elle est moins profonde. Peu d'écrivains ont obtenu plus de succès. Il reduisit à la portée du vulgaire la science de la pensée, en retranchant tout ce qu'elle avoit d'élevé. Chacun fut surpris et glorieux de pouvoir philosopher si facilement; et l'on eut une grande reconnoissance pour celui à qui l'on devoit ce bienfait. On ne s'apperçut pas qu'il avoit rabaissé la science, au lieu de rendre ses disciples capable d'y atteindre."—(*Tableau de la Litterature Françoise pendant le dix-huitième Siècle*, pp. 87. 88. 89. 92.)

"The First Book (says Dr Beattie) of the *Essay on Human Understanding*, which, with submission, I think the worst, tends to establish this dangerous doctrine, that the human mind, previous to education and habit, is as susceptible of any one impression as of any other:—a doctrine which, if true, would go near to prove, that truth and virtue are no better than human contrivances; or at least, that they have nothing permanent in their nature, but may be as changeable as the inclinations and capacities of men." Dr Beattie, however, candidly and judiciously adds, "Surely this is not the doctrine that Locke *meant* to establish; but his zeal against innate ideas, and innate principles, put him off his guard, and made him allow too little to instinct, for fear of allowing too much."

In this last remark, I perfectly agree with Dr Beattie; although I am well aware, that a considerable number of Locke's English disciples have not only chosen to interpret the first book of his *Essay* in that very sense in which it appeared to Dr Beattie to be of so mischievous a tendency, but have avowed Locke's doctrine, when thus interpreted, as their own ethical creed. In this number, I am sorry to say, the respectable name of Paley must be included.[1]

It is fortunate for Locke's reputation, that, in other parts of his *Essay*, he has disavowed, in the most unequivocal terms, those dangerous conclusions which, it must be owned, the general strain of his first book has too much the appearance of favouring. "He that hath the idea (he observes on one occasion) of an intelligent, but frail and weak being, made by and depending on another, who is omnipotent, perfectly wise, and good, will as certainly know, that man is to honour, fear, and obey God, as that the sun shines when he sees it; nor can he be surer, in a clear morning, that the sun is risen, if he will but open his eyes, and turn them that way. But yet these truths being never so certain, never so clear, he may be ignorant of either, or all of them, who will never take the pains to employ his faculties as he should to inform himself about them." To the same purpose, he has elsewhere said, that "there is a *Law of Nature*, as intelligible to a *rational creature and studier of that law*, as the positive laws of commonwealths." Nay, he has himself, in the most explicit terms, anticipated and disclaimed those dangerous consequences which, it has been so often supposed, it was the chief scope of this introductory chapter to establish. "I would not be mistaken, as if, because I deny an innate law, I thought there were none but positive laws. There is a great deal of difference between an innate law and a law of nature; between something imprinted on our minds in their very original, and something that we, being ignorant of, may attain to the knowledge of, by the use and due application of our natural faculties. And I think they equally forsake the truth, who, running into the contrary extremes, either affirm an innate law, or deny that there is a law knowable by the light of nature, without the help of a positive revelation." (Vol. I. p. 44.) Nor was Locke unaware of the influence on men's lives of their speculative tenets concerning these metaphysical and ethical questions. On this point, which can alone render such discussions interesting to human happiness, he has expressed himself thus: "Let that principle of some of the philosophers, that *all is matter, and that there is nothing else*, be received for certain and indubitable, and it will be easy to be seen, by the writings of some that have revived it again in our days, what consequences it will lead into....Nothing can be so dangerous as principles thus taken up without due questioning or examination; especially if they be such as influence men's lives, and give a bias to all their actions. He that with *Archelaus* shall lay it down as a principle, that right and wrong, honest and dishonest, are defined only by laws, and not by nature, will have other measures of moral rectitude and pravity, than those who take it for granted, that we are under obligations antecedent to all human constitutions."—(Vol. III. p. 75.) Is not the whole of this passage evidently pointed at the Epicurean maxims of Hobbes and of Gassendi?[1]

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[1] See *Principles of Moral and Political Philosophy*, Book I. Chap. 5, where the author discusses the question concerning a *moral sense*.

Lord Shaftesbury was one of the first who sounded the alarm against what he conceived to be the drift of that philosophy which denies the existence of *innate principles.* Various strictures on this subject occur in the *Characteristics;* particularly in the treatise entitled *Advice to an Author;* but the most direct of all his attacks upon Locke is to be found in his 8th Letter, addressed to a Student at the University. In this letter he observes, that " all those called *free writers* now-a-days have espoused those principles which Mr Hobbes set a foot in this last age."—" Mr Locke (he continues), as much as I honour him on account of other writings (on Government, Policy, Trade, Coin, Education, Toleration, &c.) and as well as I knew him, and can answer for his sincerity as a most zealous Christian and believer, did however go in the self-same tract; and is followed by the Tindals, and all the other free authors of our times!

" 'Twas Mr Locke that struck the home blow: for Mr Hobbes's character, and base slavish principles of government, took off the poison of his philosophy. 'Twas Mr Locke that struck at all fundamentals, threw all *order and virtue* out of the world, and made the very ideas of these (which are the same with those of God) *unnatural*, and without foundation in our minds. *Innate* is a word he poorly plays upon: the right word, though less used, is *connatural.* For what has *birth* or progress of the fœtus out of the womb to do in this case?—the question is not about the *time* the ideas entered, or the moment that one body came out of the other; but whether the constitution of man be such, that, being adult and grown up,[2] at such a time, sooner or later (no matter when,) the idea and sense of *order, administration*, and a God, will not infallibly, inevitably, necessarily spring up in him."

In this last remark Shaftesbury appears to me to place the question about *innate ideas* upon the right and only philosophical footing; and to afford a key to all the confusion running through Locke's argument against their existence. The sequel of the above quotation is not less just and valuable—but I must not indulge myself in any farther extracts. It is sufficient to mention the perfect coincidence between the opinion of Shaftesbury, as here stated by himself, and that formerly quoted in the words of Locke; and, of consequence, the injustice of concluding, from some unguarded expressions of the latter, that there was, at bottom, any essential difference between their real sentiments.[3]

Under the title of Locke's *Metaphysical* (or, to speak with more strict precision, his *Logical*) writings, may also be classed his tracts on Education, and on the Conduct of the Understand-

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[1] To the above quotations from Locke, the following deserves to be added: " Whilst the parties of men cram their tenets down all men's throats, whom they can get into their power, without permitting them to examine their truth or falsehood, and will not let truth have fair play in the world, nor men the liberty to search after it; what improvements can be expected of this kind? What greater light can be hoped for in the moral sciences? The subject part of mankind in most places might, instead thereof, with Egyptian bondage expect Egyptian darkness, *were not the candle of the Lord set up by himself in men's minds, which it is impossible for the breath or power of man wholly to extinguish.*"—Vol. II. pp. 343, 344.

[2] Lord Shaftesbury should have said, " grown up to the possession and exercise of his reasoning powers."

[3] I must, at the same time, again repeat, that the facts and reasonings contained in the introduction to Locke's *Essay* go very far to account for the severity of Shaftesbury's censures on this part of his work. Sir Isaac Newton himself, an intimate friend of Locke's, appears, from a letter of his which I have read in his own handwriting, to have felt precisely in the same manner with the author of the *Characteristics.* Such, at least, were his *first* impressions; although he afterwards requested, with a humility and candour worthy of himself, the forgiveness of Locke, for this injustice done to his character. " I beg your pardon (says he) for representing that you struck at the root of morality in a principle you laid down in your book of ideas, and designed to pursue in another book; and that I took you for a Hobbist." In the same letter Newton alludes to certain unfounded suspicions which he had been led to entertain of the propriety of Locke's conduct in some of their private concerns; adding, with an ingenuous and almost infantine simplicity, ' I was so much affected with this, that when one told me you was sickly and would not live, I answered, 'twere better if you were dead. I desire you to forgive me this uncharitableness." The letter is subscribed, *your most humble and most unfortunate servant, Is. Newton.**

The rough draft of Mr Locke's reply to these afflicting acknowledgments was kindly communicated to me by a friend some years ago. It is written with the magnanimity of a philosopher, and with the good-humoured forbearance of a man of the world; and it breathes throughout so tender and so unaffected a veneration for the good as well as great qualities of the excellent person to whom it is addressed, as demonstrates at once the conscious integrity of the writer, and the superiority of his mind to the irritation of little passions. I know of nothing from Locke's pen which does more honour to his ing. These tracts are entirely of a practical nature, and were plainly intended for a wider circle of readers than his *Essay;* but they everywhere bear the strongest marks of the same zeal for extending the empire of Truth and of Reason, and may be justly regarded as parts of the same great design.[1] It has been often remarked, that they display less originality than might have been expected from so bold and powerful a thinker; and, accordingly, both of them have long fallen into very general neglect. It ought, however, to be remembered, that, on the most important points discussed in them, new suggestions are not now to be looked for; and that the great object of the reader should be, not to learn something which he never heard of before, but to learn, among the multiplicity of discordant precepts current in the world, *which* of them were sanctioned, and *which* reprobated by the judgment of Locke. The candid and unreserved thoughts of such a writer upon such subjects as Education, and the culture of the intellectual powers, possess an intrinsic value, which is not diminished by the consideration of their triteness. They not only serve to illustrate the peculiarities of the author's own character and views, but, considered in a practical light, come recommended to us by all the additional weight of his discriminating experience. In this point of view, the two tracts in question, but more especially that on the *Conduct of the Understanding*, will always continue to be interesting manuals to such as are qualified to appreciate the mind from which they proceeded.[2]

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* It is dated *at the Bull in Shoreditch, London, September* 1693; and is addressed, *For John Locke, Esq. at Sir Fra. Masham's, Bart. at Oates, in Essex.*

It must not, however, be concluded from the *apparent* triteness of some of Locke's remarks, to the present generation of readers, that they were viewed in the same light by his own contempo-

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temper and character; and I introduce it with peculiar satisfaction, in connection with those strictures which truth has extorted from me on that part of his system which to the moralist stands most in need of explanation and apology.

MR LOCKE TO MR NEWTON.

"Sir, *Oates*, 5*th October* 93.

"I have been ever since I first knew you so kindly and sincerely your friend, and thought you so much mine, that I could not have believed what you tell me of yourself, had I had it from any body else. And though I cannot but be mightily troubled that you should have had so many wrong and unjust thoughts of me, yet, next to the return of good offices, such as from a sincere good will I have ever done you, I receive your acknowledgment of the contrary as the kindest thing you could have done me, since it gives me hopes I have not lost a friend I so much valued. After what your letter expresses, I shall not need to say anything to justify myself to you: I shall always think your own reflection on my carriage both to you and all mankind will sufficiently do that. Instead of that, give me leave to assure you, that I am more ready to forgive you than you can be to desire it; and I do it so freely and fully that I wish for nothing more than the opportunity to convince you that I truly love and esteem you; and that I have still the same good will for you as if nothing of this had happened. To confirm this to you more fully, I should be glad to meet you anywhere, and the rather, because the conclusion of your letter makes me apprehend it would not be wholly useless to you. I shall always be ready to serve you to my utmost, in any way you shall like, and shall only need your commands or permission to do it.

"My book is going to press for a second edition; and, though I can answer for the design with which I writ it, yet, since you have so opportunely given me notice of what you have said of it, I should take it as a favour if you would point out to me the places that gave occasion to that censure, that, by explaining myself better, I may avoid being mistaken by others, or unwillingly doing the least prejudice to truth or virtue. I am sure you are so much a friend to both, that, were you none to me, I could expect this from you. But I cannot doubt but you would do a great deal more than this for my sake, who, after all, have all the concern of a friend for you, wish you extremely well, and am, without compliment," &c. &c.

(For the preservation of this precious memorial of Mr Locke, the public is indebted to the descendants of his friend and relation the Lord Chancellor King, to whom his papers and library were bequeathed. The original is still in the possession of the present representative of that noble family; for whose flattering permission to enrich my Dissertation with the above extracts, I feel the more grateful, as I have not the honour of being personally known to his Lordship.)

[1] Mr Locke, it would appear, had once intended to publish his thoughts on the Conduct of the Understanding, as an additional chapter to his Essay. "I have lately," says he, in a Letter to Mr Molyneux, "got a little leisure to think of some additions to my book against the next edition, and within these few days have fallen upon a subject that I know not how far it will lead me. I have written several pages on it, but the matter, the farther I go, opens the more upon me, and I cannot get sight of any end of it. The title of the chapter will be, *Of the Conduct of the Understanding*, which, if I shall pursue as far as I imagine it will reach, and as it deserves, will, I conclude, make the largest chapter of my Essay." (LOCKE's *Works*, Vol. IX. p. 407.)

[2] A similar remark may be extended to a letter from Locke to his friend Mr Samuel Bold, who had complained to him of the disadvantages he laboured under from a weakness of memory. It contains nothing but what might have come from the pen of one of Newberry's authors; but with what additional interest do we read it, when considered as a comment by Locke on a suggestion of Bacon's!—(LOCKE's *Works*, Vol. X. p. 317.)

It is a judicious reflection of Shenstone's, that "every single observation published by a man of genius, be it ever so trivial, should be esteemed of importance, because he speaks from his own impressions; whereas common men publish common things, which they have perhaps *gleaned* from frivolous writers. I know of few authors to whom this observation applies more forcibly and happily than to Locke, when he touches on the culture of the intellectual powers. His precepts, indeed, are not all equally sound; but they, in general, contain a large proportion of truth, and may always furnish to a speculative mind matter of useful meditation.

raries. On the contrary, Leibnitz speaks of the *Treatise on Education* as a work of still greater merit than the *Essay on Human Understanding.*[1] Nor will this judgment be wondered at by those who, abstracting from the habits of thinking in which they have been reared, transport themselves in imagination to the state of Europe a hundred years ago. How flat and nugatory seem now the cautions to parents about watching over those associations on which the dread of spirits in the dark is founded! But how different was the case (even in Protestant countries) till a very recent period of the last century!

I have, on a former occasion, taken notice of the slow but (since the invention of printing) certain steps by which Truth makes its way in the world; "the discoveries, which, in one age, are confined to the studious and enlightened few, becoming, in the next, the established creed of the learned; and, in the third, forming part of the elementary principles of education." The harmony, in the meantime, which exists among truths of all descriptions, tends perpetually, by blending them into one common mass, to increase the joint influence of the whole; the contributions of individuals to this mass (to borrow the fine allusion of Middleton) "resembling the drops of rain, which, falling separately into the water, mingle at once with the stream, and strengthen the general current." Hence the ambition, so natural to weak minds, to distinguish themselves by paradoxical and extravagant opinions; for *these*, having no chance to incorporate themselves with the progressive reason of the species, are the more likely to immortalise the eccentricity of their authors, and to furnish subjects of wonder to the common compilers of literary history. This ambition is the more general, as so little expence of genius is necessary for its gratification. "Truth (as Mr Hume has well observed) is *one thing*, but errors are numberless;" and hence (he might have added) the difficulty of seizing the former, and the facility of swelling the number of the latter.[2]

Having said so much in illustration of Locke's philosophical merits, and in reply to the common charge against his metaphysical and ethical principles, it now only remains for me to take notice of one or two defects in his intellectual character, which exhibit a strong contrast to the general vigour of his mental powers.

Among these defects, the most prominent is, the facility with which he listens to historical evidence, when it happens to favour his own conclusions. Many remarkable instances of this occur in his long and rambling argument (somewhat in the style of Montaigne) against the existence of *innate practical principles;* to which may be added, the degree of credit he appears to have given to the popular tales about mermaids, and to Sir William Temple's idle story of Prince Maurice's "rational and intelligent parrot." Strange! that the same person who, in matters of reasoning, had divested himself, almost to a fault, of all reverence for the opinions of others, should have failed to perceive, that, of all the various sources of error, one of the most copious and fatal is an unreflecting faith in human testimony!

The disrespect of Locke for the wisdom of antiquity, is another prejudice which has frequently given a wrong bias to his judgment. The idolatry in which the Greek and Roman writers were held by his immediate predecessors, although it may help to account for this weakness, cannot altogether excuse it in a man of so strong and enlarged an understanding. Locke (as we are told by Dr Warton) "*affected* to depreciate the ancients; which circumstance (he adds), as I am informed from undoubted authority, was the source of perpetual discontent and dispute betwixt him and his pupil, Lord Shaftesbury ; who, in many parts of the *Characteristics*, has ridiculed Locke's philosophy, and endeavoured to represent him as a disciple of Hobbes." To those who are aware of the direct opposition between the principles of Hobbes, of Montaigne, of Gassendi, and of the other *minute philosophers* with whom Locke sometimes seems unconsciously to unite his strength,—and the principles of Socrates, of Plato, of Cicero, and of all the soundest moralists, both of ancient and of modern times, the foregoing anecdote will serve at once to explain and to palliate the acrimony of some of Shaftesbury's strictures on Locke's Ethical paradoxes.[1]

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[1] Leib. *Op.* Tom. VI. p. 226.

[2] Descartes has struck into nearly the same train of thinking with the above, but his remarks apply much better to the writings of Locke than to his own.

"L'expérience m'apprit, que quoique mes opinions surprennent d'abord, parce qu'elles sont fort différentes des vulgaires, cependant, après qu'on les a comprises on les trouve si simples et si conformes au sens commun, qu'on cesse entièrement de les admirer, et par la même d'en faire cas: parceque tel est le naturel des hommes qu'ils n'estiment que les choses qui leur laissent d'admiration et qu'ils ne possedent pas tout-a-fait. C'est ainsi que quoique la santé soit le plus grand de tous les biens qui concernent le corps, c'est pourtant celui auquel nous faisons le moins de réflexion, et que nous goutons le moins. Or, la connoissance de la vérité est comme la santé de l'âme; lorsque on la possède on n'y pense plus."—*Lettres*, Tome I. Lettre xliii.)

With this disposition of Locke to depreciate the ancients, was intimately connected that contempt which he everywhere expresses for the study of Eloquence, and that perversion of taste which led him to consider Blackmore as one of the first of our English poets.[2] That his own imagination was neither sterile nor torpid, appears sufficiently from the agreeable colouring and animation which it has not unfrequently imparted to his style : but *this* power of the mind he seems to have regarded with a peculiarly jealous and unfriendly eye ; confining his view exclusively to its occasional effects in misleading the judgment, and overlooking altogether the important purposes to which it is subservient, both in our intellectual and moral frame. Hence, in all his writings, an inattention to those more attractive aspects of the mind, the study of which (as Burke has well observed) " while it communicates to the taste a sort of philosophical solidity, may be expected to reflect back on the severer sciences some of those graces and elegancies, without which the greatest proficiency in these sciences will always have the appearance of something illiberal."

To a certain hardness of character, not unfrequently united with an insensibility to the charms of poetry and of eloquence, may partly be ascribed the severe and forbidding spirit which has suggested some of the maxims in his *Tract on Education.*[3] He had been treated, himself, it would appear, with very little indulgence by his parents ; and probably was led by that filial veneration which he always expressed for their memory, to ascribe to the early habits of self-denial imposed on him by their ascetic system of ethics, the existence of those moral qualities which he owed to the regulating influence of his own reason in fostering his natural dispositions ; and which, under a gentler and more skilful culture, might have assumed a still more engaging and amiable form. His father, who had served in the Parliament's army, seems to have retained through life that austerity of manners which characterised his puritanical associates ; and, notwithstanding the comparative enlargement and cultivation of Mr Locke's mind, something of this hereditary leaven, if I am not mistaken, continued to operate upon many of his opinions and habits of thinking. If, in the *Conduct of the Understanding*, he trusted (as many have thought) too much to nature, and laid too little stress on logical rules, he certainly fell into the opposite extreme in everything connected with the culture of the heart ; distrusting nature altogether, and placing his sole confidence in the effects of a systematical and vigilant discipline. That the great object of education is not to thwart and disturb, but to study the aim, and to facilitate the accomplishment of her beneficial arrangements, is a maxim, one should think, obvious to common sense ; and yet it is only of late years that it has begun to gain ground even among philosophers. It is but justice to Rousseau to acknowledge, that the zeal and eloquence with which he has enforced it, go far to compensate the mischievous tendency of some of his other doctrines.

To the same causes it was probably owing, that Locke has availed himself so little in his *Conduct of the Understanding*, of his own favourite doctrine of the Association of Ideas. He has been, indeed, at sufficient pains to warn parents and guardians of the mischievous consequences to be apprehended from this part of our constitution, if not diligently watched over in our infant years. But he seems to have altogether overlooked the positive and immense resources which might be derived from it, in the culture and amelioration, both of our intellectual and moral powers;—in strengthening (for instance), by early *habits* of right thinking, the authority of reason and of conscience;—in blending with our best feelings the congenial and ennobling sympathies of taste and of fancy;—and in identifying, with the first workings of the imagination, those pleasing views of the order of the universe, which are so essentially necessary to human happiness. A law of our nature, so mighty and so extensive in its influence, was surely not given to man in vain; and the fatal *purchase* which it has, in all ages, afforded to Machiavellian statesmen, and to political religionists, in carrying into effect their joint conspiracy against the improvement and welfare of our species, is the most decisive proof of the manifold uses to which it might be turned in the hands of instructors, well disposed and well qualified humbly to co-operate with the obvious and unerring purposes of Divine Wisdom.

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[1] Plebeii Philosophi (says Cicero) qui a Platone et Socrate, et ab ea familia dissident.

[2] " All our English poets, except Milton," says Molyneux in a letter to Locke, " have been mere ballad-makers in comparison to Sir Richard Blackmore." In reply to which Locke says, " There is, I with pleasure find, a strange harmony throughout between your thoughts and mine."—(LOCKE's *Works*, Vol. IX. pp. 423, 426.)

[3] Such, for example, as this, that " a child should never be suffered to have what he craves, or *so much as speaks for*, much less if he cries for it !" A maxim (as his correspondent Molyneux observes) " which seems to bear hard on the tender spirits of children, and the natural affections of parents."—(LOCKE's *Works*, Vol. IX. p. 319.)

A more convenient opportunity will afterwards occur for taking some notice of Locke's writings on Money and Trade, and on the Principles of Government. They appear to me to connect less naturally and closely with the literary history of the times when they appeared, than with the systematical views which were opened on the same subjects about fifty years afterwards, by some speculative politicians in France and in England. I shall, therefore, delay any remarks on them which I have to offer till we arrive at the period when the questions to which they relate began everywhere to attract the attention of the learned world, and to be discussed on those general principles of expediency and equity, which form the basis of the modern science of Political Economy. With respect to his merits as a logical and metaphysical reformer, enough has been already said for this introductory section: but I shall have occasion, more than once, to recur to them in the following pages, when I come to review those later theories, of which the germs or rudiments may be distinctly traced in his works; and of which he is, therefore, entitled to divide the praise with such of his successors as have reared to maturity the prolific seeds scattered by his hand.[1]

SECTION II.

Continuation of the Review of Locke and Leibnitz.

LEIBNITZ.

Independently of the pre-eminent rank, which the versatile talents and the universal learning of Leibnitz entitle him to hold among the illustrious men who adorned the Continent of Europe during the eighteenth century, there are other considerations which have determined me to unite his name with that of Locke, in fixing the commencement of the period, on the history of which I am now to enter. The school of which he was the founder was strongly discriminated from that of Locke, by the general spirit of its doctrines; and to this school a large proportion of the metaphysicians, and also of the mathematicians of Germany, Holland, France, and Italy, have ever since his time had a decided leaning. On the fundamental question, indeed, concerning the *Origin of our Knowledge*, the philosophers of the Continent (with the exception of the Germans, and a few eminent individuals in other countries) have, in general, sided with Locke, or rather with Gassendi; but, in most other instances, a partiality for the opinions, and a deference for the authority of Leibnitz, may be traced in their speculations, both on metaphysical and physical subjects. Hence a striking contrast between the characteristical features of the continental philosophy, and those of the contemporary systems which have succeeded each other in our own island; the great proportion of our most noted writers, notwithstanding the opposition of their sentiments on particular points, having either attached themselves, or professed to attach themselves, to the method of inquiry recommended and exemplified by Locke.

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[1] And yet with what modesty does Locke speak of his own pretensions as a Philosopher! "In an age that produces such masters as the great Huygenius and the incomparable Mr Newton, it is ambition enough to be employed as an underlabourer in clearing the ground a little, and removing some of the rubbish that lies in the way to knowledge."—(*Essay on Human Understanding. Epistle to the Reader.*) See Note Z.

But the circumstance which chiefly induced me to assign to Leibnitz so prominent a place in this historical sketch, is the extraordinary influence of his industry and zeal, in uniting, by a mutual communication of intellectual lights and of moral sympathies, the most powerful and leading minds scattered over Christendom. Some preliminary steps towards such an union had been already taken by Wallis in England, and by Mersenne in France; but the *literary commerce*, of which they were the centres, was confined almost exclusively to Mathematics and to Physics; while the comprehensive correspondence of Leibnitz extended alike to every pursuit interesting to man, either as a speculative or as an active being. From this time forward, accordingly, the history of philosophy involves, in a far greater degree than at any former period, the general history of the human mind; and we shall find, in our attempts to trace its farther progress, our attention more and more irresistibly withdrawn from local details to more enlarged views of the globe which we inhabit. A striking change in this literary commerce among nations took place, at least in the western parts of Europe, before the death of Leibnitz; but, during the remainder of the last century, it continued to proceed with an accelerated rapidity over the whole face of the civilised world. A multitude of causes, undoubtedly, conspired to produce it; but I know of no individual whose name is better entitled than that of Leibnitz, to mark the era of its commencement.[1]

I have already, in treating of the philosophy of Locke, said enough, and perhaps more than enough, of the opinion of Leibnitz concerning the origin of our knowledge. Although expressed in a different phraseology, it agrees in the most essential points with the *innate ideas* of the Cartesians; but it approaches still more nearly to some of the mystical speculations of Plato. The very exact coincidence between the language of Leibnitz on this question, and that of his contemporary Cudworth, whose mind, like his own, was deeply tinctured with the Platonic Metaphysics, is not unworthy of notice here, as an historical fact; and it is the only remark on this part of his system which I mean to add at present to those in the preceding history.

"The *seeds* of our acquired knowledge," says Leibnitz, "or, in other words, our *ideas*, and the eternal truths which are derived from them, are contained in the mind itself; nor is this wonderful, since we know by our own consciousness, that we possess within ourselves the ideas of *existence*, of *unity*, of *substance*, of *action*, and other ideas of a similar nature." To the same purpose, we are told by Cudworth, that "the mind contains in itself virtually (as the future plant or tree is contained in the *seed*) general notions of all things which unfold and discover themselves as occasions invite, and proper circumstances occur."

The metaphysical theories, to the establishment of which Leibnitz chiefly directed the force of his genius, are the doctrine of *Pre-established Harmony;* and the scheme of *Optimism,* as new modelled by himself. On neither of these heads will it be necessary for me long to detain my readers.

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[1] The following maxims of Leibnitz deserve the serious attention of all who have at heart the improvement of mankind: "On trouve dans le monde plusieurs personnes bien intentionnées; mais le mal est, qu'elles ne s'entendent point, et ne travaillent point de concert. S'il y avoit moyen de trouver une espéce de glu pour les reunir, on feroit quelque chose. Le mal est souvent que les gens de bien ont quelques caprices ou opinions particulières, qui font qu'ils sont contraires entr'eux...........L'esprit sectaire consiste proprement dans cette prétention de vouloir que les autres se reglent sur nos maximes, au lieu qu'on se devroit contenter de voir qu'on aille au but principal."—(LEIB. *Op.* Tom. I. p. 740.)

1. According to the system of *Pre-established Harmony,* the human mind and human body are two independent but constantly correspondent machines;—adjusted to each other like two unconnected clocks, so constructed, that, at the same instant, the one should *point* the hour, and the other *strike* it. Of this system the following summary and illustration are given by Leibnitz himself, in his Essay entitled *Theodicæa:*

"I cannot help coming into this notion, that God created the *soul* in such manner at first, that it should *represent* within itself all the simultaneous changes in the body; and that he has made the body also in such manner, as that it must of itself do what the soul wills:—So that the laws which make the thoughts of the soul follow each other in regular succession, *must* produce *images* which shall be coincident with the impressions made by external objects upon our organs of sense; while the laws by which the motions of the body follow each other, are likewise so coincident with the thoughts of the soul, as to give to our *volitions* and *actions* the very same appearance, as if the latter were really the natural and the necessary consequences of the former."—(Leib. *Op.* I. p. 163.) Upon another occasion he observes, that "every thing goes on in the soul as if it had no body, and that every thing goes on in the body as if it had no soul." (*Ibid.* II. p. 44.)

To convey his meaning still more fully, Leibnitz borrows from Mr Jaquelot[1] a comparison, which, whatever may be thought of its justness, must be at least allowed some merit in point of ingenuity. "Suppose that an intelligent and powerful being, who knew, beforehand, every particular thing that I should order my footman to do to-morrow, should make a machine to resemble my footman exactly, and punctually to perform, all day, whatever I directed. On this supposition, would not *my will* in issuing all the details of my orders, remain, in every respect, in the same circumstances as before? And would not my machine-footman, in performing his different movements, have the appearance of acting only in obedience to my commands?" The inference to be drawn from this comparison is, that the movements of my body have no direct dependence whatever on the volitions of my mind, any more than the actions of my machine-footman would have on the words issuing from my lips. The same inference is to be extended to the relation which the *impressions* made on my different senses bear to the co-existent perceptions arising in my mind. The impressions and perceptions have no mutual *connection,* resembling that of physical causes with their effects; but the one series of events is made to correspond invariably with the other, in consequence of an eternal *harmony* between them *pre-established* by their common Creator.

From this outline of the scheme of *Pre-established Harmony,* it is manifest, that it took its rise from the very same train of thinking which produced Malebranche's doctrine of *Occasional Causes.* The authors of both theories saw clearly the impossibility of tracing the mode in which mind acts on body, or body on mind; and hence were led rashly to conclude, that the *connection* or *union* which seems to exist between them is not real, but apparent. The inferences, however, which they drew from this common principle were directly opposite; Malebranche maintaining, that the communication between mind and body was carried on by the immediate and incessant agency of the Deity; while Leibnitz conceived, that the agency of God was employed only in the original contrivance and mutual adjustment of the two machines;—all the subsequent phenomena of each being the necessary results of its own independent mechanism, and, at the same time, the progressive evolutions of a comprehensive design, harmonising the laws of the one with those of the other.

Of these two opposite hypotheses, that of Leibnitz is by far the more unphilosophical and untenable. The chief objection to the doctrine of

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[1] Author of a Book entitled *Conformité de la Foi avec la Raison.*

occasional causes is, that it presumes to decide upon a question of which human reason is altogether incompetent to judge;—our ignorance of the mode in which matter acts upon mind, or mind upon matter, furnishing not the shadow of a proof that the one may not act directly and immediately on the other, in some way incomprehensible by our faculties.[1] But the doctrine of *Pre-established Harmony*, besides being equally liable to this objection, labours under the additional disadvantage of involving a perplexed and totally inconsistent conception of the nature of *Mechanism;*—an inconsistency, by the way, with which all those philosophers are justly chargeable, who imagine that, by likening the universe to a machine, they get rid of the necessity of admitting the constant agency of powers essentially different from the known qualities of matter. The word *Mechanism* properly expresses a combination of natural powers to produce a certain effect. When such a combination is successful, a machine, once set a-going, will sometimes continue to perform its office for a considerable time, without requiring the interposition of the artist: And hence we are led to conclude, that the case may perhaps be similiar with respect to the universe, when once put into motion by the Deity. This idea Leibnitz carried so far as to exclude the supposition of any subsequent agency in the first contriver and mover, excepting in the case of a miracle. But the falseness of the analogy appears from this, that the moving force in every machine is some *natural power*, such as gravity or elasticity; and, consequently, the very idea of mechanism assumes the existence of those active powers, of which it is the professed object of a mechanical theory of the universe to give an explanation. Whether, therefore, with Malebranche, we resolve every effect into the immediate agency of God, or suppose, with the great majority of Newtonians, that he employs the instrumentality of second causes to accomplish his purposes, we are equally forced to admit with Bacon, the necessity not only of a first contriver and mover, but of his constant and efficient concurrence (either immediately or mediately) in carrying his design into execution:—" *Opus* (says Bacon) *quod operatur Deus a primordio usque ad finem.*"

In what I have now said I have confined myself to the idea of *Mechanism* as it applies to the material universe; for, as to this word, when applied by Leibnitz to the mind, which he calls a *Spiritual Automaton*, I confess myself quite unable to annex a meaning to it: I shall not, therefore, offer any remarks on this part of his system.[1]

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[1] The mutual action, or (as it was called in the schools) the mutual *influence (influxus)* of soul and body, was, till the time of Descartes, the prevailing hypothesis, both among the learned and the vulgar. The reality of this *influx*, if not positively denied by Descartes, was at least mentioned by him as a subject of doubt; but by Malebranche and Leibnitz it was confidently rejected as absurd and impossible. (See their works *passim.)* Gravesande, who had a very strong leaning towards the doctrines of Leibnitz, had yet the good sense to perceive the inconclusiveness of his reasoning in this particular instance, and states in opposition to it the following sound and decisive remarks: " Non concipio, quomodo mens in corpus agere possit; non etiam video, quomodo ex motu nervi perceptio sequatur; non tamen inde sequi mihi apparet, omnem *influxum* esse rejiciendum.

" Substantiæ incognitæ sunt. Jam videmus naturam mentis nos latere; scimus hanc esse aliquid, quod ideas habet, has confert, &c. sed ignoramus quid sit subjectum, cui hæ proprietates conveniant.

" Hoc idem de corpore dicimus; est extensum, impenetrabile, &c. sed quid est quod habet hasce proprietates? Nulla nobis via aperta est, qua ad hanc cognitionem pervenire possimus.

" Inde concludimus, multa nos latere, quæ proprietates mentis et corporis spectant.

" Invicta demonstratione constat, non mentem in corpus, neque hoc in illam agere, ut corpus in corpus agit; sed mihi non videtur inde concludi posse, omnem *influxum* esse impossibilem.

" Motu suo corpus non agit in aliud corpus, sine resistente; sed an non actio, omnino diversa, et cujus ideam non habemus, in aliam substantiam dari possit, et ita tamen, ut causa effectui respondeat, in re adeo obscura, determinare non ausim. Difficile certe est influxum negare, quando exacte perpendimus, quomodo in minimis quæ mens percipit, relatio detur cum agitationibus in corpore, et quomodo hujus motus cum mentis determinationibus conveniant. Attendo ad illa quæ medici, et anatomici, nos de his docent.

" Nihil, ergo, de systemate *influxus* determino, præter hoc, mihi nondum hujus impossibilitatem satis clare demonstratam esse videri."—*(Introductio ad Philosophiam.)* See Note A A.

With respect to the *manner* in which the intercourse between Mind and Matter is carried on, a very rash assertion escaped Mr Locke in the first edition of his *Essay*. " The next thing to be considered is, how bodies produce ideas in us, *and that is manifestly by impulse, the only way which we can conceive bodies operate in.*"—*(Essay*, B. II. ch. viii. § 11.)

In the course of Locke's controversial discussions with the Bishop of Worcester, he afterwards became fully sensible of this important oversight; and he had the candour to acknowledge his error in the following terms: " 'Tis true, I have said, that bodies operate by impulse, and nothing else. And so I thought when I writ it, and can yet conceive no other way of their operations. But I am since convinced, by the judicious Mr Newton's incomparable book, that it is too bold a presumption to limit God's power in this point by my narrow conceptions. * * * * * * And, therefore, in the next edition of my book, I will take care to have that passage rectified."

It is a circumstance that can only be accounted for by the variety of Mr Locke's other pursuits, that in all the later editions of the *Essay* which have fallen in my way, the proposition in question has been allowed to remain as it originally stood.

To these visionary speculations of Leibnitz, a strong and instructive contrast is exhibited in the philosophy of Locke; a philosophy, the main object of which is less to enlarge our knowledge, than to make us sensible of our ignorance; or (as the author himself expresses it) " to prevail with the busy mind of man to be cautious in meddling with things exceeding its comprehension; to stop when it is at the utmost extent of its tether; and to sit down in a quiet ignorance of those things, which, upon examination, are found to be beyond the reach of our capacities." ......" My right hand writes," says Locke, in another part of his *Essay*, " whilst my left hand is still. What causes rest in one, and motion in the other? Nothing but my will, a thought of my mind; my thought only changing, my right hand rests, and the left hand moves. *This is matter of fact which cannot be denied.* Explain this and make it intelligible, and then the next step will be to understand Creation......In the meantime, it is an overvaluing ourselves, to reduce all to the narrow measure of our capacities; and to conclude all things impossible to be done, whose manner of doing exceeds our comprehension......If you do not understand the operations of your own finite Mind, that thinking thing within you, do not deem it strange that you cannot comprehend the operations of that eternal infinite Mind, who made and governs all things, and whom the heaven of heavens cannot contain."[2]—(Vol. II. pp. 249, 250.)

This contrast between the philosophical characters of Locke and of Leibnitz is the more deserving of notice, as something of the same sort has ever since continued to mark and to discriminate the metaphysical researches of the English and of the German schools. Various exceptions to this remark may, no doubt, be mentioned; but these exceptions will be found of trifling moment, when compared with the indisputable extent of its general application.

The theory of pre-established harmony led, by a natural and obvious transition, to the scheme of Optimism. As it represented all events, both in the physical and moral worlds, as the necessary effects of a mechanism originally contrived and set a-going by the Deity, it reduced its author to the alternative of either calling in question the Divine power, wisdom, and goodness, or of asserting that the universe which he had called into being was the best of all possible systems. This last opinion, accordingly, was eagerly embraced by Leibnitz; and forms the subject of a work entitled *Theodicæa*, in which are combined together, in an extraordinary degree, the acuteness of the logician, the imagination of the poet, and the impenetrable, yet sublime darkness, of the metaphysical theologian.[3]

The modification of Optimism, however, adopted by Leibnitz, was, in some essential respects, peculiar to himself. It differed from that of Plato, and of some other sages of antiquity, in considering the human mind in the light of *a spiritual machine*, and, of consequence, in positively denying the freedom of human actions. According to Plato, every thing is right, so far as it is the work of God;—the creation of beings endowed with free will, and consequently liable to moral delinquency—and the government of the world by general laws, from which occasional evils *must* result,—furnishing no objection to the perfection of the universe, to which a satisfactory reply may not be found in the partial and narrow views of it, to which our faculties are at present confined. But he held at the same time, that, although the permission of moral evil does not detract from the goodness of God, it is nevertheless imputable to man as a fault, and renders him justly obnoxious to punishment. This system (under a variety of forms) has been in all ages maintained by the wisest and best philosophers, who, while they were anxious to vindicate the perfections of God, saw the importance of stating their doctrine in a manner not inconsistent with man's free will and moral agency.

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[1] Absurd as the hypothesis of a *Pre-established Harmony* may now appear, not many years have elapsed since it was the prevailing, or rather universal creed, among the philosophers of Germany. " Il fut un temps" (says the celebrated Euler, " où le systême de l'harmonie pré-établie etoit tellement en vogue dans toute l'Allemagne, que ceux qui en doutoient, passoient pour des ignorans, ou des esprits bornés."—(*Lettres de* M. Euler *à une Princesse d'Allemagne*, 83*e* Lettre.) It would be amusing to reckon up the succession of metaphysical creeds which have been since swallowed with the same implicit faith by this learned and speculative, and (in all those branches of knowledge where imagination has no influence over the judgment) profound and inventive nation.

[2] That this is a fair representation of the scope of Locke's philosophy, according to the author's own view of it, is demonstrated by the two mottos prefixed to the *Essay on Human Understanding*. The one is a passage of the book of *Ecclesiastes*, which, from the place it occupies in the front of his work, may be presumed to express what he himself regarded as the most important moral to be drawn from his speculations. " As thou knowest not what is the way of the spirit, nor how the bones do grow in the womb of her that is with child; even so, thou knowest not the works of God, who maketh all things." The other motto (from Cicero) strongly expresses a sentiment which every competent judge must feel on comparing the above quotations from Locke, with the *monads* and the *pre-established harmony* of Leibnitz. " Quam bellum est velle confiteri potius nescire quod nescias, quam ista effutientem nauseare, atque ipsum sibi displicere !" See Note B B.

[3] " La Théodicée seule (says Fontenelle) suffiroit pour representer M. Leibnitz. Une lecture immense, des anecdotes curieuses sur les livres ou les personnes, beaucoup d'équité et même de faveur pour tous les auteurs cités, fut ce en les combattant; des vues sublimes et lumineuses, des raisonnemens au fond desquels on sent toujours l'esprit géometrique, un style où la force domine, et où cependant sont admis les agrémens d'une imagination heureuse."—*Eloge de Leibnitz.*

The scheme of Optimism, on the contrary, as proposed by Leibnitz, is completely subversive of these cardinal truths. It was, indeed, viewed by the great and excellent author in a very different light; but in the judgment of the most impartial and profound inquirers, it leads, by a short and demonstrative process, to the annihilation of all moral distinctions.[1]

It is of great importance to attend to the distinction between these two systems; because it has, of late, become customary among sceptical writers, to confound them studiously together, in order to extend to both that ridicule to which the latter is justly entitled. This, in particular, was the case with Voltaire, who, in many parts of his later works, and more especially in his *Candide*, has, under the pretence of exposing the extravagancies of Leibnitz, indulged his satirical raillery against the order of the universe. The success of his attempt was much aided by the confused and inaccurate manner in which the scheme of optimism had been recently stated by various writers, who, in their zeal to "vindicate the ways of God," had been

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[1] It is observed by Dr Akenside, that "the Theory of Optimism has been delivered of late, especially abroad, in a manner which subverts the freedom of human actions; whereas Plato appears very careful to preserve it, and has been in that respect imitated by the best of his followers."—(Notes on the 2d Book of the *Pleasures of the Imagination.)*

I am perfectly aware, at the same time, that different opinions have been entertained of Plato's real sentiments on this subject; and I readily grant that passages with respect to Fate and Necessity may be collected from his works, which it would be very difficult to reconcile with any one consistent scheme.—(See the Notes of Mosheim on his Latin Version of Cudworth's *Intellectual System*, Tome. I. pp. 10. 310, *et seq.* Lugd. Batav. 1773.)

Without entering at all into this question, I may be permitted here to avail myself, for the sake of conciseness, of Plato's name, to distinguish that modification of optimism which I have opposed in the text to the optimism of Leibnitz. The following sentence, in the 10th Book *De Republica*, seems sufficient of itself to authorise this liberty:—'Αρετὴ δὲ ἀδέσποτον, ἣν τιμῶν καὶ ἀτιμάζων, πλέον καὶ ἔλαττον αὐτῆς ἕκαστος ἕξει. αἰτία ἑλομένου. Θεὸς ἀναίτιος. *Virtus inviolabilis ac libera quam prout honerabit quis aut negliget, ita plus aut minus ex ea possidebit. Eligentis quidem culpa est omnis. Deus vero extra culpam.*

A short abstract of the allegory with which Leibnitz concludes his *Theodicæa*, will convey a clearer idea of the scope of that work, than I could hope to do by any metaphysical comment. The groundwork of this allegory is taken from a dialogue on Free-Will, written by Laurentius Valla, in opposition to Boethius;—in which dialogue, Sextus, the son of Tarquin the Proud, is introduced as consulting Apollo about his destiny. Apollo predicts to him that he is to violate Lucretia, and afterwards, with his family, to be expelled from Rome. *(Exul inopsque cades irata pulsus ub urbe.)* Sextus complains of the prediction. Apollo replies, that the fault is not his; that he has only the gift of seeing into futurity;* that all things are regulated by Jupiter; and that it is to him his complaint should be addressed. *(Here finishes the allegory of Valla, which Leibnitz thus continues, agreeably to his own principles.)* In consequence of the advice of the Oracle, Sextus goes to Dodona to complain to Jupiter of the crime which he is destined to perpetrate. "Why (says he), oh Jupiter! have you made me wicked and miserable? Either change my lot and my will, or admit that the fault is yours, not mine." Jupiter replies to him: "Renounce all thoughts of Rome and of the crown; be wise, and you shall be happy. If you return to Rome you are undone." Sextus, unwilling to submit to such a sacrifice, quits the Temple, and abandons himself to his fate.

After his departure, the high priest, Theodorus, asks Jupiter why he had not given another *Will* to Sextus. Jupiter sends Theodorus to Athens to consult Minerva. The goddess shows him the Palace of the Destinies, where are representations of all possible worlds,† each of them containing a Sextus Tarquinius with a different *Will*, leading to a catastrophe more or less happy. In the last and best of these worlds, forming the summit of the pyramid composed by the others, the high priest sees Sextus go to Rome, throw every thing into confusion, and violate the wife of his friend. "You see" (says the Goddess of Wisdom) "it was not my father that made Sextus wicked. He was wicked from all eternity, and he was always so in consequence of his own will.‡ Jupiter has only bestowed on him that existence which he could not refuse him in the best of all possible worlds. He only transferred him from the region of *possible* to that of *actual* beings. What great led to hazard principles more dangerous in their consequences, than the prejudices and errors which it was their aim to correct.[1]

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* "Futura novi, non facio."

† *World* (it must be remembered) is here synonymous with *Universe.*

‡ "Vides Sextum a Patre meo non fuisse factum improbum, talis quippe ab omni æternitate fuit, et quidem semper libere; existere tantum ei concessit Jupiter, quod ipsum profecto ejus sapientia mundo, in quo ille continebatur, denegare non poterat: ergo Sextum e regione possibilium ad rerum existentium classem transtulit."

The zeal of Leibnitz in propagating the dogma of Necessity is not easily reconcileable with the hostility which, as I have already remarked, he uniformly displays against the congenial doctrine of Materialism. Such, however, is the fact, and I believe it to be quite unprecedented in the previous history of philosophy. Spinoza himself has not pushed the argument for necessity further than Leibnitz,—the reasonings of both concluding not less forcibly against the free-will of God than against the free-will of man, and, of consequence, terminating ultimately in *this* proposition, that no event in the universe could possibly have been different from what has actually taken place.[3] The *distinguishing* feature of this article of the Leibnitzian creed is, that, while the Hobbists and Spinozists were employing their ingenuity in connecting together Materialism and Necessity, as branches springing from one common root, Leibnitz always speaks of the soul as a machine purely *spiritual*,[3]—a machine, however, as necessarily regulated by pre-ordained and immutable laws, as the movements of a clock or the revolutions of the planets. In consequence of holding this language, he seemed to represent Man in a less degrading light than other necessitarians; but, in as far as such speculative te-

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events does the crime of Sextus draw after it? The liberty of Rome—the rise of a government fertile in civil and military virtues, and of an empire destined to conquer and to civilise the earth." Theodorus returns thanks to the goddess, and acknowledges the justice of Jupiter.

[1] Among this number must be included the author of the *Essay on Man*, who, from a want of precision in his metaphysical ideas, has unconsciously fallen into various expressions, equally inconsistent with each other and with his own avowed opinions:

If plagues and earthquakes break not Heaven's design,
Why then a Borgia or a Catiline?—
Who knows but He whose hand the lightning forms,
Who heaves old Ocean, and who wings the storms,
Pours fierce ambition on a Cæsar's mind,
Or turns young Ammon loose to scourge mankind?—

* * * * *

—The general order since the whole began,
Is kept in Nature, and is kept in Man.

This approaches very nearly to the optimism of Leibnitz, and has certainly nothing in common with the optimism of Plato. Nor is it possible to reconcile it with the sentiments inculcated by Pope in other parts of the same poem.

What makes all physical and moral ill?
There deviates Nature, and here wanders Will.

In this last couplet he seems to admit, not only that *Will* may *wander*, but that *Nature* herself may *deviate* from the *general order;* whereas the doctrine of his universal prayer is, that, while the material world is subjected to established laws, man is left to be the arbiter of his own destiny:

Yet gav'st me in this dark estate
To know the good from ill,
And, binding Nature fast in fate,
Left free the human will.

In the Dunciad, too, the scheme of *Necessity* is coupled with that of *Materialism*, as one of the favourite doctrines of the sect of free-thinkers.

Of nought so certain as our *Reason* still,
Of nought so doubtful as of *Soul* and *Will*.

"Two things" (says Warburton, who professes to speak Pope's sentiments) "the most self-evident, the existence of our souls and the freedom of our will!"

[2] So completely, indeed, and so mathematically linked, did Leibnitz conceive all truths, both physical and moral, to be with each other, that he represents the eternal geometrician as incessantly occupied in the solution of this problem,—*The State of one Monad (or elementary atom) being given, to determine the state, past, present, and future, of the whole universe.*

[3] "Cuncta itaque in homine certa sunt, et in antecessum determinata, uti in cæteris rebus omnibus, et anima humana est *spirituale quoddam automatum*."—Leib. *Op.* Tom. I. p. 156.

In a note on this sentence, the editor quotes a passage from Bilfinger, a learned German, in which an attempt is made to vindicate the propriety of the phrase, by a reference to the etymology of the word *automaton*. This word, it is observed, when traced to its source, literally expresses something which contains within itself its principle of motion, and, consequently, it applies still more literally to *Mind* than to a machine. The remark, considered in a philological point of view, is indisputably just; but is it not evident, that it leads to a conclusion precisely contrary to what this author would deduce from it? Whatever may have been the primitive meaning of the word, its common, or rather its universal meaning, even among scientific writers, is, a *material* machine, moving without any foreign impulse; and, that this was the idea annexed to it by Leibnitz, appears from his distinguishing it by the epithet *spirituale*,—an epithet which would have been altogether superfluous had he intended to convey the opinion ascribed to him by Bilfinger. In applying, therefore, this language to the mind, we may conclude, with confidence, that Leibnitz had no intention to contrast together mind and body, in respect of their moving or actuating principles, but only to contrast them in respect of the *substances* of which they are composed. In a word, he conceived both of them to be equally *machines*, made and wound up by the Supreme Being; but the machinery in the one case to be material, and in the other spiritual.

nets may be supposed to have any practical effect on human conduct, the tendency of his doctrines is not less dangerous than that of the most obnoxious systems avowed by his predecessors.[1]

The scheme of necessity was still farther adorned and sublimed in the *Theodicæa* of Leibnitz, by an imagination nurtured and trained in the school of Plato. "May there not exist," he asks on one occasion, "an immense space beyond the region of the stars? and may not this *empyreal* heaven be filled with happiness and glory? It may be conceived to resemble an ocean, where the rivers of all those created beings that are destined for bliss shall finish their course, when arrived in the starry system, at the perfection of their respective natures."—(Leib. *Op.* Tom. I. p. 135.)[2]

In various other instances, he rises from the deep and seemingly hopeless abyss of *Fatalism*, to the same lofty conceptions of the universe; and has thus invested the most humiliating article of the atheistic creed, with an air of Platonic mysticism. The influence of his example appears to me to have contributed much to corrupt the taste and to bewilder the speculations of his countrymen; giving birth, in the last result, to that heterogeneous combination of all that is pernicious in Spinozism, with the transcendental eccentricities of a heated and exalted fancy, which, for many years past, has so deeply tinctured both their philosophy and their works of fiction.[3]

In other parts of Europe, the effects of the *Theodicæa* have not been equally unfavourable. In France, more particularly, it has furnished to the few who have cultivated with success the Philosophy of Mind, new weapons for combating the materialism of the Gassendists and Hobbists; and, in England, we are indebted to it for the irresistible reasonings by which Clarke subverted the foundations on which the whole superstructure of Fatalism rests.[4]

It may be justly regarded as a proof of the progress of reason and good sense among the Metaphysicians of this country since the time of Leibnitz, that the two theories of which I have been speaking, and which, not more than a century ago, were honoured by the opposition of such an antagonist as Clarke, are now remembered only as subjects of literary history.—In the arguments, however, alleged in support of these theories, there are some *logical* principles involved, which still continue to have an extensive influence over the reasonings of the learned, on questions seemingly the most remote from all metaphysical conclusions. The two most prominent of these are, the principle of the *Sufficient Reason*, and the *Law of Continuity;* both of them so intimately connected with some of the most celebrated disputes of the last century, as to require a more particular notice than may, at first sight, seem due to their importance.

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[1] The following remark in Madame de Staël's interesting and eloquent review of German philosophy bears marks of a haste and precipitation with which her criticisms are seldom chargeable: "Les opinions de Leibnitz tendent surtout au perfectionnement moral, s'il est vrai, comme les philosophes Allemands ont taché de le prouver, que le libre arbitre repose sur la doctrine qui affranchit l'âme des objets exterieures, et que la vertu ne puisse exister sans la parfaite independance du vouloir."

[2] The celebrated *Charles Bonnet*, in his work entitled, *Contemplation de la Nature*, has indulged his imagination so far, in following out the above conjecture of Leibnitz, as to rival some of the wildest flights of Jacob Behmen. "Mais l'échelle de la création ne se termine point au plus élevés des mondes planétaires. Là commence un autre univers, dont l'étendue est peut-être à celle de l'univers des *Fixes*, ce qu'est l'espace du systéme solaire à la capacité d'une noix.

"Là, comme des Astres resplendissans, brillent les Hierarchies Celestes.

"Là rayonnent de toutes parts les Anges, les Archanges, les Seraphins, les Cherubins, les Trones, les Vertus, les Principautés, les Dominations, les Puissances.

"Au centre de ces Augustes Spheres, éclate le Soleil de Justice, l'Orient d'Enhaut, dont tous les Astres empruntent leur lumière et leur splendeur."

"La *Theodicée* de Leibnitz," the same author tells us in another passage, "est un de mes livres de devotion: J'ai intitulé mon Exemplaire, *Manuel de Philosophie Chrétienne*."

[3] "The gross appetite of Love (says Gibbon) becomes most dangerous when it is elevated, or rather disguised, by sentimental passion." The remark is strikingly applicable to some of the most popular novels and dramas of Germany; and something very similar to it will be found to hold with respect to those speculative extravagancies which, in the German systems of philosophy, are *elevated or disguised* by the imposing cant of moral enthusiasm.

In one of Leibnitz's controversial discussions with Dr Clarke, there is a passage which throws some light on his taste, not only in matters of science, but in judging of works of imagination. "Du temps de M. Boyle, et d'autres excellens hommes qui fleurissoient en Angleterre sous Charles II. on n'auroit pas osé nous debiter *des notions si creuses*. *(The notions here alluded to are those of Newton concerning the law of gravitation.)* J'espére que le beautemps reviendra sous un aussi bon gouvernement que celui d'à present. Le capital de M. Boyle etoit d'inculquer que tout se faisoit *méchaniquement* dans la physique. Mais c'est un malheur des hommes, de se degouter enfin de la raison même, et de s'ennuyer de la lumière. Les chimères commencent à revenir, et plaisent parce qu'elles ont quelque chose de merveilleux. Il arrive dans le pays philosophique ce qui est arrivé dans le pays poetique. On s'est lassé des romans raisonnables, tel que *la Clélie Françoise* ou *l'Aramene Allemande*; et on est revenu depuis quelque temps aux *Contes des Fées*."—(*Cinquième Ecrit de* M. Leibnitz, p. 266.)

From this passage it would seem, that Leibnitz looked forward to the period, when the dreams of the Newtonian philosophy would give way to some of the exploded mechanical theories of the universe; and when the *Fairy-tales* then in fashion (among which number must have been included those of Count Anthony Hamilton) would be supplanted by the revival of such *reasonable Romances* as the *Grand Clelia*. In neither of these instances does there seem to be much probability, at present, that his prediction will be ever verified.

The German writers, who, of late years, have made the greatest noise among the sciolists of this country, will be found less indebted for their fame to the new lights which they have struck out, than to the unexpected and grotesque forms in which they have combined together the materials supplied by the invention of former ages, and of other nations. It is this combination of truth and error in their philosophical systems, and of right and wrong in their works of fiction, which has enabled them to perplex the understandings, and to unsettle the principles of so many, both in Metaphysics and Ethics. In point of profound and extensive erudition, the scholars of Germany still continue to maintain their long established superiority over the rest of Europe.

[4] A very interesting account is given by Leibnitz, of the circumstances which gave occasion to his *Theodicæa*, in a letter

I. Of the principle of the *Sufficient Reason*, the following succinct account is given by Leibnitz himself, in his controversial correspondence with Dr Clarke: "The great foundation of Mathematics is the principle of *contradiction* or *identity;* that is, that a proposition cannot be true and false at the same time. But, in order to proceed from Mathematics to Natural Philosophy, another principle is requisite (as I have observed in my *Theodicæa*); I mean, the principle of the *Sufficient Reason;* or, in other words, that nothing happens without a *reason* why it should be so, rather than otherwise: And, accordingly, Archimedes was obliged, in his book *De Æquilibrio*, to take for granted, that if there be a balance, in which every thing is alike on both sides, and if equal weights are hung on the two ends of that balance, the whole will be at rest. It is because no *reason* can be given why one side should weigh down rather than the other. Now, by this single principle of the *Sufficient Reason*, may be demonstrated the being of a God, and all the other parts of Metaphysics or Natural Theology; and even, in some measure, those physical truths that are independent of Mathematics, such as the Dynamical Principles, or the Principles of Forces."

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to a Scotch gentleman, Mr Burnet of Kemney; to whom he seems to have unbosomed himself on all subjects without any reserve: "Mon livre intitulé *Essais de Theodicée*, sur la bonté de Dieu, la liberté de l'homme, et l'origine de mal, sera bientôt achevé. La plus grande partie de cet ouvrage avoit été faite par lambeaux, quand je me trouvois chez la feue Reine de Prusse, où ces matières étoient souvent agitées à l'occasion du Dictionnaire et des autres ouvrages de M. Bayle, qu'on y lisoit beaucoup. Après la mort de cette grande Princesse, j'ai rassemblé et augmenté ces piéces sur l'exhortation des amis qui en étoient informés, et j'en ai fait l'ouvrage dont je viens de parler. Comme j'ai medité sur cette matière depuis ma jeunesse, je pretends de l'avoir discutée à fond."—(Leibnitz, *Opera*, Tom. VI. p. 284.)

In another letter to the same correspondent, he expresses himself thus:

"La plupart de mes sentimens ont été enfin arrêtés après une délibération de 20 ans: car j'ai commencé bien jeune à méditer, et je n'avois pas encore 15 ans, quand je me promenois des journées entières dans un bois, pour prendre parti entre Aristote et Democrite. Cependant j'ai changé et réchangé sur des nouvelles lumières, et ce n'est que depuis environ 12 ans que je me trouve satisfait, et que je suis arrivé à des demonstrations sur ces matières qui n'en paroissent point capables: Cependant de la manière que je m'y prends, ces démonstrations peuvent être sensibles comme celles des nombres, quoique le sujet passe l'imagination."—(*Ibid.* p. 253.)

The letter from which this last paragraph is taken is dated in the year 1697.

My chief reason for introducing these extracts, was to do away an absurd suspicion, which has been countenanced by some respectable writers (among others by Le Clerc), that the opinions maintained in the *Theodicée* of Leibnitz were not his real sentiments, and that his own creed, on the most important questions there discussed, was not very different from that of Bayle. Gibbon has even gone so far as to say, that "in his defence of the attributes and providence of the Deity, he was suspected of a secret correspondence with his adversary."—(*Antiquities of the House of Brunswick.*) In support of this very improbable charge, I do not know that any evidence has ever been produced, except the following passage, in a letter of his, addressed to a Professor of Theology in the University of Tubingen (Pfaffius):—"Ita prorsus est, vir summe reverende, uti scribis, de Theodicæa mea. Rem acu tetigisti; et miror, neminem hactenus fuisse, qui sensum hunc meum senserit. Neque enim Philosophorum est rem serio semper agere; qui in fingendis hypothesibus, uti bene mones, ingenii sui vires experiuntur. Tu, qui Theologus, in refutandis erroribus Theologum agis." In reply to this it is observed, by the learned editor of Leibnitz's works, that it is much more probable that Leibnitz should have expressed himself on this particular occasion in jocular and ironical terms, than that he should have wasted so much ingenuity and learning in support of an hypothesis to which he attached no faith whatever; an hypothesis, he might have added, with which the whole principles of his philosophy are systematically, and, as he conceived, mathematically connected. It is difficult to believe, that among the innumerable correspondents of Leibnitz, he should have selected a Professor of Theology at Tubingen, as the sole depository of a secret which he was anxious to conceal from all the rest of the world.

Surely a solitary document such as this weighs less than nothing, when opposed to the details quoted in the beginning of this note; not to mention its complete inconsistency with the character of Leibnitz, and with the whole tenor of his writings.

For my own part, I cannot help thinking, that the passage in question has far more the air of *persiflage* provoked by the vanity of Pfaffius, than of a serious compliment to his sagacity and penetration. No injunction to secrecy, it is to be observed, is here given by Leibnitz to his correspondent.

Some of the inferences deduced by Leibnitz from this almost gratuitous assumption are so paradoxical, that one cannot help wondering he was not a little staggered about its certainty. Not only was he led to conclude, that the mind is necessarily determined in all its elections by the influence of motives, insomuch that it would be impossible for it to make a choice between two things perfectly alike; but he had the boldness to extend this conclusion to the Deity, and to assert, that two things perfectly alike could not have been produced even by Divine Power. It was upon this ground that he rejected a *vacuum*, because all the parts of it would be perfectly like to each other; and that he also rejected the supposition of *atoms*, or similar particles of matter, and ascribed to each particle a *monad*, or active principle, by which it is discriminated from every other particle.[1] The application of his principle, however, on which he evidently valued himself the most, was that to which I have already alluded; the demonstrative evidence with which he conceived it to establish the impossibility of free-agency, not only in man, but in any other intelligent being:[2] a conclusion which, under whatever form of words it may be disguised, is liable to every objection which can be urged against the system of Spinoza.

With respect to the principle from which these important consequences were deduced, it is observable, that it is stated by Leibnitz in terms so general and vague, as to extend to all the different departments of our knowledge; for he tells us, that there must be a *sufficient reason* for every *existence*, for every *event*, and for every *truth*. This use of the word *reason* is so extremely equivocal, that it is quite impossible to annex any precise idea to the proposition. Of this it is unnecessary to produce any other proof than the application which is here made of it to things so very different as *existences*, *events*, and *truths*; in all of which cases, it must of necessity have different meanings. It would be a vain attempt, therefore, to combat the maxim in the form in which it is commonly appealed to: Nor, indeed, can we either adopt or reject it, without considering particularly how far it holds in the various instances to which it may be applied.

The multifarious discussions, however, of a physical, a metaphysical, and a theological nature,[3] necessarily involved in so detailed an examination, would, in the present times (even if this were a proper place for introducing them), be equally useless and uninteresting; the peculiar opinions of Leibnitz on most questions connected with these sciences having already fallen into complete neglect. But as the maxim still continues to be quoted by the latest advocates for the scheme of necessity, it may not be altogether superfluous to observe, that, when understood to refer to the changes that take place in the *material* universe, it coincides entirely with the common maxim, that "every change implies the operation of a *cause*;" and that it is in consequence of its intuitive evidence in this particular case, that so many have been led to acquiesce in it, in the unlimited terms in which Leibnitz has announced it. One thing will be readily granted, that the maxim, when applied to the determinations of intelligent and moral *agents*, is not *quite* so obvious and indisputable, as when applied to the changes that take place in things altogether inanimate and passive.

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[1] See Note C C.

[2] The following comment on this part of the Leibnitzian system is from the pen of one of his greatest admirers, *Charles Bonnet*: "Cette Métaphysique transcendante deviendra un peu plus intelligible, si l'on fait attention, qu'en vertu du principe de la *raison suffisante*, tout est necessairement lié dans l'univers. Toutes les Actions des Etres Simples sont harmoniques, ou subordonnées les unes aux autres. L'exercice actuel de l'activité d'une monade donnée, est determiné par l'exercice actuel de l'activité des monades auxquelles elle correspond immédiatement. Cette correspondance continue d'un point quelconque de l'univers jusqu'à ses extremités. Représentez-vouz les ordres circulaires et concentriques qu'une pierre excite dans une eau dormante: Elles vont toujours en s'élargissant et en s'affoiblissant.

"Mais, l'état actuel d'une monade est nécessairement determiné par son état antécédent: Celui-ci par un état qui a precédé, et ainsi en remontant jusqu'à l'instant de la creation. * * * * * *

"Ainsi le passé, le présent, et le futur ne forment dans la même monade qu'une seul chaine. Notre philosophe disoit ingénieusement, que *le présent est toujours gros de l'avenir*.

"Il disoit encore que l'Eternel Geómetre resolvoit sans cesse ce Problème; l'état d'une monade étant donné. en déterminer l'état passé, présent, et futur de tout l'univers."—Bonnet, Tom. VIII. p. 303, 304, 305.)

[3] Since the time of Leibnitz, the principle of the *sufficient reason* has been adopted by some mathematicians as a legitimate mode of reasoning in plane geometry; in which case, the application made of it has been in general just and logical, notwithstanding the vague and loose manner in which it is expressed. In this science, however, the use of it can never be attended with much advantage; except perhaps in demonstrating a few elementary truths (such as the 5th and 6th propositions of Euclid's first book), which are commonly established by a more circuitous process: and, even in these instances, the spirit of the reasoning might easily be preserved under a different form, much less exceptionable in point of phraseology.

What then, it may be asked, induced Leibnitz, in the enunciation of his maxim, to depart from the form in which it has generally been stated, and to substitute, instead of the word *cause*, the word *reason*, which is certainly not only the more unusual, but the more ambiguous expression of the two? Was it not evidently a perception of the impropriety of calling the motives from which we act the *causes* of our actions; or, at least of the inconsistency of this language with the common ideas and feelings of mankind? The word *reason* is *here* much less suspicious, and much more likely to pass current without examination. It was therefore with no small dexterity, that Leibnitz contrived to express his general principle in such a manner, that the impropriety of his language should be most apparent in that case in which the proposition is instantaneously admitted by every reader as self-evident; and to adapt it, in its most precise and definite shape, to the case in which it was in the greatest danger of undergoing a severe scrutiny. In this respect, he has managed his argument with more address than Collins, or Edwards, or Hume, all of whom have applied the maxim to *mind*, in the very same words in which it is usually applied to inanimate matter.

But on this article of Leibnitz's philosophy, which gave occasion to his celebrated controversy with Clarke, I shall have a more convenient opportunity to offer some strictures, when I come to take notice of another antagonist, more formidable still, whom Clarke had soon after to contend with on the same ground. The person I allude to is Anthony Collins, a writer certainly not once to be compared with Leibnitz, in the grasp of his intellectual powers; but who seems to have studied this particular question with greater attention and accuracy, and who is universally allowed to have defended his opinions concerning it in a manner far more likely to mislead the opinions of the multitude.

II. The same remark which has been already made on the principle of the *Sufficient Reason* may be extended to that of the *Law of Continuity*. In both instances the phraseology is so indeterminate, that it may be interpreted in various senses essentially different from each other; and, accordingly, it would be idle to argue against either principle as a general theorem, without attending separately to the specialties of the manifold cases which it may be understood to comprehend. Where such a latitude is taken in the enunciation of a proposition, which, so far as it is true, must have been inferred from an induction of particulars, it is at least possible that, while it holds in *some* of its applications, it may yet be far from possessing any claim to that universality which seems necessarily to belong to it, when considered in the light of a metaphysical axiom, resting on its own intrinsic evidence.

Whether this vagueness of language was the effect of artifice, or of a real vagueness in the author's notions, may perhaps be doubted; but that it has contributed greatly to extend his reputation among a very numerous class of readers, may be confidently asserted. The possession of a general maxim, sanctioned by the authority of an illustrious name, and in which, as in those of the schoolmen, *more* seems to *be meant than meets the ear*, affords of itself no slight gratification to the vanity of many; nor is it inconvenient for a disputant, that the maxims to which he is to appeal should be stated in so dubious a shape, as to enable him, when pressed in an argument, to shift his ground at pleasure, from one interpretation to another. The extraordinary popularity which, in our own times, the philosophy of Kant enjoyed, for a few years, among the countrymen of Leibnitz, may, in like manner, be in a great degree ascribed to the imposing aspect of his enigmatical oracles, and to the consequent facility of arguing without end, in defence of a system so transmutable and so elusive in its forms.

The extension, however, given to the *Law of Continuity*, in the later publications of Leibnitz, and still more by some of his successors, has been far greater than there is any reason to think was originally in the author's contemplation. It first occurred to him in the course of one of his physical controversies, and was probably suggested by the beautiful exemplifications of it which occur in pure geometry. At that time it does not appear that he had the slightest idea of its being susceptible of any application to the objects of natural history; far less to the succession of events in the intellectual and moral worlds. The supposition of bodies *perfectly hard*, having been shown to be inconsistent with two of his leading doctrines, *that* of the constant maintenance of the same quantity of force in the Universe, and *that* of the proportionality of forces to the squares of the velocities,—he found himself reduced to the necessity of asserting, that all changes are produced by insensible gradations, so as to render it impossible for a body to have its state changed from motion to rest, or from rest to motion, without passing through all the intermediate states of velocity. From this assumption he argued, with much ingenuity, that the existence of atoms, or of perfectly hard bodies, is impossible; because, if two of them should meet with equal and opposite motions, they would necessarily stop at once, in violation of the *law of continuity*. It would, perhaps, have been still more logical, had he argued against the universality of a law so gratuitously assumed, from its incompatibility with an hypothesis, which, whether true or false, certainly involves nothing either contradictory or improbable: but as this inversion of the argument would have undermined some of the fundamental principles of his physical system, he chose rather to adopt the other alternative, and to announce the *law of continuity* as a metaphysical truth, which admitted of no exception whatever. The facility with which this *law* has been adopted by subsequent philosophers is not easily explicable; more especially, as it has been maintained by many who reject those physical errors, in defence of which Leibnitz was first led to advance it.

One of the earliest, and certainly the most illustrious, of all the partizans and defenders of this principle, was John Bernouilli, whose discourse on motion first appeared at Paris in 1727, having been previously communicated to the Royal Academy of Sciences, in 1724 and 1726.[1] It was from this period it began to attract the general attention of the learned; although many years were yet to elapse, before it was to acquire that authority which it now possesses among our most eminent mathematicians.

Mr Maclaurin, whose Memoir on the *Percussion of Bodies* gained the prize from the Royal Academy of Sciences, in 1724, continued from that time, till his death, the steady opposer of this new *law*. In his Treatise of *Fluxions*, published in 1742, he observes, that "the existence of hard bodies void of elasticity has been rejected for the sake of what is called the *Law of Continuity*; a law which has been *supposed* to be general, without sufficient ground."[2] And still more explicitly, in his *Posthumous Account of Newton's Philosophical Discoveries*, he complains of those who "have rejected hard bodies as impossible, from far-fetched and metaphysical considerations;" proposing to his adversaries this unanswerable question, "Upon what grounds is the *law of continuity* assumed as an universal law of nature?"[3]

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[1] "En effet (says Bernouilli), un pareil principe de dureté (the supposition to wit of bodies perfectly hard) ne sçauroit exister; c'est une chimère qui répugne à cette loi générale que la nature observe constamment dans toutes ses opérations; je parle de cet ordre immuable et perpétuel établi depuis la création de l'univers, *qu'on peut appeller* LOI DE CONTINUITÉ, en vertu de laquelle tout ce qui s'exécute, s'exécute par des degrés infiniment petits. Il semble que le bon sens dicte, qu'aucun changement ne peut se faire *par saut; natura non operatur per saltum;* rien ne peut passer d'une extremité à l'autre, sans passer par tous les degrés du milieu," &c. The continuation of this passage (which I have not room to quote) is curious, as it suggests an argument, in proof of the *law of continuity*, from the principle of the *sufficient reason.*

It may be worth while to observe here, that though, in the above quotation, Bernouilli speaks of the *law of continuity* as an arbitrary arrangement of the Creator, he represents, in the preceding paragraph, the idea of perfectly hard bodies, as involving a manifest contradiction.

[2] Maclaurin's *Fluxions*, Vol. II. p. 438.

[3] Nearly to the same purpose Mr Robins, a mathematician and philosopher of the highest eminence, expresses himself thus: "M. Bernouilli (in his *Discours sur les Lois de la Communication du Mouvement)*, in order to prove that there are no bodies perfectly hard and inflexible, lays it down as an immutable law of nature, that no body can pass from motion to rest instantaneously, or without having its velocity gradually diminished. That this is a law of nature, M. Bernouilli thinks is evident from that principle, *Natura non operatur per saltum*, and from good sense. BUT HOW GOOD SENSE CAN, OF ITSELF, WITHOUT EXPERIMENT, DETERMINE ANY OF THE LAWS OF NATURE, IS TO ME VERY ASTONISHING. Indeed, from any thing M. Bernouilli has said, it would have been altogether as conclusive to have begun at the other end, and have disput-

In the speculations hitherto mentioned, the *law of continuity* is applied merely to such *successive* events in the material world as are connected together by the relation of *cause and effect;* and, indeed, *chiefly* to the changes which take place in the state of bodies with respect to *motion and rest.* But in the philosophy of Leibnitz, we find the same *law* appealed to as an indisputable principle in all his various researches, physical, metaphysical, and theological. He extends it with the same confidence to mind as to matter, urging it as a demonstrative proof, in opposition to Locke, that the soul never ceases to think even in sleep or in *deliquium;*[1] nay, inferring from it the impossibility that, in the case of any animated being, there should be such a thing as *death,* in the literal sense of that word.[2] It is by no means probable that the author was at all aware, when he first introduced this principle into the theory of motion, how far it was to lead him in his researches concerning other questions of greater moment; nor does it appear that it attracted much notice from the learned, but as a new *mechanical* axiom, till a considerable time after his death.

Charles Bonnet of Geneva, a man of unquestionable talents and of most exemplary worth, was, as far as I know, the first who entered fully into the views of Leibnitz on this point; perceiving how inseparably the law of continuity (as well as the principle of the sufficient reason) was interwoven with his scheme of universal concatenation and mechanism; and inferring from thence not only all the paradoxical corollaries deduced from it by its author, but some equally bold conclusions of his own, which Leibnitz either did not foresee in their full extent, or to which the course of his inquiries did not particularly attract his attention. The most remarkable of these conclusions was, that all the various beings which compose the universe, form a scale descending downwards without any chasm or *saltus*, from the Deity to the simplest forms of unorganised matter;[3] a proposition not altogether new in the history of philosophy, but which I do not know that any writer before Bonnet had ventured to assert as a metaphysical and necessary truth. With what important limitations and exceptions it must be received, even when confined to the compa-

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ed, that no body can pass instantaneously from motion to rest; because it is an immutable law of nature that all bodies shall be flexible."—(Robins, Vol. II. p. 174. 175.)

In quoting these passages, I would not wish to be understood as calling in question the universality of the *Law of Continuity* in the phenomena of moving bodies; a point on which I am not led by the subject of this discourse to offer any opinion; but on which I intend to hazard some remarks in a Note at the end of it.—See Note D D. All that I would here assert is, that it is a *law*, the truth of which can be inferred only by an induction from the phenomena; and to which, accordingly, we are not entitled to say that there cannot possibly exist any exceptions.

[1] "Je tiens que l'âme, et même le corps, n'est jamais sans action, et que l'âme n'est jamais sans quelque perception; même en dormant on a quelque sentiment confus et sombre du lieu où l'on est, et d'autres choses. *Mais quand l'expérience ne le confirmeroit pas, je crois qu'il y en a démonstration.* C'est à peu près comme on ne sçauroit prouver absolument par les expériences, s'il n'y a point de vuide dans l'espace, et s'il n'y a point de repos dans la matière. Et cependant ces questions me paroissent decidées démonstrativement, aussi bien qu'à M. Locke."—(Leib. *Op.* Tome II. p. 220.)

[2] See Note E E.

[3] "Leibnitz admettoit comme un principe fondamental de sa sublime philosophie, qu'il n'y a jamais de sauts dans la nature, et que tout est continu ou nuancé dans le physique et dans le moral. C'étoit sa fameuse *Loi de Continuité*, qu'il croyoit retrouver encore dans les mathématiques, et ç'avoit été cette loi qui lui avoit inspiré la singulière prédiction dont je parlois."[*] "Tous les êtres, disoit il, ne forment qu'une seule chaine, dans laquelle les différentes classes, comme autant d'anneaux, tiennent si étroitement les unes aux autres, qu'il est impossible aux sens et à l'imagination de fixer précisément le point où quelqu'un commence ou finit: toutes les espèces qui bordent ou qui occupent, pour ainsi dire, les régions d'inflection, et de rebroussement, devoit être équivoques et douées de caractères qui peuvent se rapporter aux espèces voisins également. Ainsi, l'existence des zoophytes ou *Plant-Animaux* n'a rien de monstrueux; mais il est même convenable à l'ordre de la nature qu'il y en ait. Et telle est la force du principe de continuité chez moi, que non seulement je ne serois point étonné d'apprendre, qu'on eut trouvé des êtres, qui par rapport à plusieurs propriétés, par exemple, celle de se nourrir ou de se multiplier, puissent passer pour des végétaux à aussi bon droit que pour des animaux, . . . J'en serois si peu étonné, dis-je, que même je suis convaincu qu'il doit y en avoir de tels, que l'Histoire Naturelle parviendra peut-être à connoître un jour," &c. &c.—(*Contemplation de la Nature*, pp. 341. 342.)

Bonnet, in the sequel of this passage, speaks of the words of Leibnitz, as a prediction of the discovery of the *Polypus*, deduced from the *Metaphysical* principle of the Law of Continuity. But would it not be more philosophical to regard it as a query founded on the *analogy* of nature, as made known to us by experience and observation?[†]

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[*] La prédiction de la découverte des Polypes.

[†] Ad eum modum summus opifex rerum seriem concatenavit a planta ad hominem, ut quasi sine ullo cohœreant intervallo; sic Ζωοφυτα cum plantis bruta conjungunt; sic cum homine simia quadrupedes. Itaque in hominis quaque specie invenimus divinos, humanos, feros.—Scaliger, (prefixed as a motto to Mr White's *Essay on the regular gradation in Man.* London, 1799.)

rative anatomy of animals, has been fully demonstrated by Cuvier;[1] and it is of material consequence to remark, that these exceptions, how few soever, to a *metaphysical* principle, are not less fatal to its truth than if they exceeded in number the instances which are quoted in support of the general rule.[2]

At a period somewhat later, an attempt has been made to connect the *same law of continuity* with the history of human improvement, and more particularly with the progress of invention in the sciences and arts. Helvetius is the most noted writer in whom I have observed this last extension of the Leibnitzian principle; and I have little doubt, from his known opinions, that, when it occurred to him, he conceived it to afford a new illustration of the scheme of necessity, and of the mechanical concatenation of all the phenomena of human life. Arguing in support of his favourite paradox concerning the original equality of all men in point of mental capacity, he represents the successive advances made by different individuals in the career of discovery, as so many imperceptible or infinitesimal steps, each individual surpassing his predecessor by a trifle, till at length nothing is wanting but an additional mind, not superior to the others in natural powers, to combine together, and to turn to its own account, their accumulated labours. " It is upon *this* mind," he observes, " that the world is always ready to bestow the attribute of genius. From the tragedies of *The Passion*, to the poets Hardy and Rotrou, and to the *Mariamne* of Tristan, the French theatre was always acquiring successively an infinite number of inconsiderable improvements. Corneille was born at a moment, when the addition he made to the art could not fail to form an epoch; and accordingly Corneille is universally regarded as a Genius. I am far from wishing," Helvetius adds, " to detract from the glory of this great poet. I wish only to prove, that *Nature never proceeds* PER SALTUM, *and that the Law of Continuity is always exactly observed.* The remarks, therefore, now made on the dramatic art, may also be applied to the sciences which rest on observation."[3]—(*De l'Esprit*, Dis. IV. Chap. I.)

With this last extension of the *Law of Continuity*, as well as with that of Bonnet, a careless reader is the more apt to be dazzled, as there is a large mixture in both of unquestionable truth. The mistake of the ingenious writers lay in pushing to *extreme cases* a doctrine, which,

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[1] *Leçons d'Anatomie Comparée.*

[2] While Bonnet was thus employing his ingenuity in generalising, still farther than his predecessors had done, the law of continuity, one of the most distinguished of his fellow citizens, with whom he appears to have been connected in the closest and most confidential friendship (the very ingenious M. Le Sage), was led, in the course of his researches concerning the physical cause of gravitation, to deny the existence of the law, even in the descent of heavy bodies. " The action of gravity (according to him) is *not* continuous." In other words, " each of its impressions is finite; and the interval of time which separates it from the following impression is of a finite duration." Of this proposition he offers a proof, which he considers as demonstrative; and thence deduces the following very paradoxical corollary, That " Projectiles do not move in curvilinear paths, but in rectilinear polygons." *—" C'est ainsi (he adds) qu'un prés, qui vu de près, se trouve couvert de parties vertes réellement separées, offre cependant aux personnes qui le regardent de loin, la sensation d'une verdure continué: Et qu'un corps poli, auquel le microscope decouvre mille solutions de continuité, paroit à l'oeil nu, posséder une continuité parfaite."

" Généralement, le simple bons sens, qui veut, qu'on suspende son jugement sur ce qu'on ignore, et que l'on ne tranche pas hardiment sur la non-existence de ce qui echappe à nos sens, auroit dû empêcher des gens qui s'appelloient philosophes de decider si dogmatiquement, la continuité réelle, de ce qui avoit une continuité apparente; et la non-existence des intervalles qu'ils n'apercevoient pas."—(*Essai de Chymie Mécanique.* Couronné en 1758, par l'Académie de Rouën: Imprimé à Genève, 1761. pp. 94. 95. 96.)

[3] It may, perhaps, be alleged, that the above allusion to the *Law of Continuity* was introduced merely for the sake of illustration, and that the author did not mean his words to be strictly interpreted; but this remark will not be made by those who are acquainted with the philosophy of Helvetius.

Let me add, that, in selecting Corneille as the only exemplification of this theory, Helvetius has been singularly unfortunate. It would have been difficult to have named any other modern poet, in whose works, when compared with those of his immediate predecessors, the *Law of Continuity* has been more remarkably violated. " Corneille (says a most judicious French critic) est, pour ainsi dire, de notre tems; mais ses contemporains n'en sont pas. *Le Cid, les Horaces, Cinna, Polieucte*, forment le commencement de cette chaine brillante qui réunit notre litterature actuelle de celle du règne de Richelieu et de la minorité de Louis XIV.; mais autour de ces points lumineux regne encore une nuit profonde; leur éclat les rapproche en apparence de nos yeux; le reste, repoussé dans l'obscurité, semble bien loin de nous. Pour nous Corneille est moderne, et Rotrou ancien," &c. (For detailed illustrations and proofs of these positions, see a slight but masterly historical sketch of the French Theatre, by M. Suard.)

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[*] " Ullas vero curvas in rerum natura esse negavere multi. Nominabo tantum, qui nunc occurrunt: *Lubinum, Bassonem. Regium, Bonartem*, et quem parum abest, quin addam *Hobbesium*."—(LEIBNITZ, *Op.* Tom. II. p. 47.)

when kept within certain limits, is not only solid but important; a mode of reasoning, which, although it may be always safely followed out in pure Mathematics (where the principles on which we proceed are mere definitions), is a never-failing source of error in all the other sciences; and which, when practically applied to the concerns of life, may be regarded as an infallible symptom of an understanding better fitted for the subtle contentions of the schools, than for those average estimates of what is expedient and practicable in the conduct of affairs, which form the chief elements of political sagacity and of moral wisdom.[1]

If on these two celebrated principles of Leibnitz, I have enlarged at greater length than may appear to some of my readers to be necessary, I must remind them, 1*st*, Of the illustration they afford of what Locke has so forcibly urged with respect to the danger of adopting, upon the faith of reasonings *a priori*, metaphysical conclusions concerning the laws by which the universe is governed: 2*dly*, Of the proof they exhibit of the strong bias of the human mind, even in the present advanced stage of experimental knowledge, to grasp at general maxims, without a careful examination of the grounds on which they rest; and of that less frequent, but not less unfortunate bias, which has led some of our most eminent mathematicians to transfer to sciences, resting ultimately on an appeal to *facts*, those habits of thinking which have been formed amidst the hypothetical abstractions of pure geometry: *Lastly*, Of the light they throw on the mighty influence which the name and authority of Leibnitz have, for more than a century past, exercised over the strongest and acutest understandings in the most enlightened countries of Europe.

It would be improper to close these reflections on the philosophical speculations of Leibnitz, without taking some notice of his very ingenious and original thoughts on the etymological study of languages, considered as a guide to our conclusions concerning the origin and migrations of different tribes of our species. These thoughts were published in 1710, in the *Memoirs* of the Berlin Academy; and form the first article of the first volume of that justly celebrated collection. I do not recollect any author of an earlier date, who seems to have been completely aware of the important consequences to which the prosecution of this inquiry is likely to lead; nor, indeed, was much progress made in it by any of Leibnitz's successors, till towards the end of the last century; when it became a favourite object of pursuit to some very learned and ingenious men, both in France, Germany, and England. *Now*, however, when our knowledge of the globe, and of its inhabitants, is so wonderfully enlarged by commerce, and by conquest; and when so great advances have been made in the acquisition of languages, the names of which, till very lately, were unheard of in this quarter of the world;—there is every reason to hope for a series of farther discoveries, strengthening progressively, by the multiplication of their mutual points of contact, the common evidence of their joint results; and tending more and more to dissipate the darkness in which the primeval history of our race is involved. It is a field, of which only detached corners have hitherto been explored; and in which, it may be confidently presumed, that unthought of treasures still lie hid, to reward sooner or later the researches of our posterity.[2]

My present subject does not lead me to speak of the mathematical and physical researches, which have associated so closely the name of Leibnitz with that of Newton, in the history of modern science; of the inexhaustible treasures of his erudition, both classical and scholastic; of his vast and manifold contributions towards the elucidation of German antiquities and of Roman jurisprudence; or of those theological controversies, in which, while he combated with one hand the enemies of revelation, he defended, with the other, the orthodoxy of his own dogmas against the profoundest and most learned divines of Europe. Nor would I have digressed so far as to allude here to these particulars, were it not for the unparalleled example they display, of what a vigorous and versatile genius, seconded by habits of persevering industry, may accomplish, within the short span of human life. Even the relaxations with which he was accustomed to fill up his moments of leisure, partook of the general character of his more serious engagements. By early and long habit, he had acquired a singular facility in the composition of Latin verses; and he seems to have delighted in loading his muse with new fetters of his own contrivance, in addition to those imposed by the laws of classical prosody.[1] The number, besides, of his literary correspondents was immense; including all that was most illustrious in Europe: and the rich materials everywhere scattered over his letters are sufficient of themselves to show, that his amusements consisted rather in a change of objects, than in a suspension of his mental activity. Yet while we admire these stupendous monuments of his intellectual energy, we must not forget (if I may borrow the language of Gibbon) that "even the powers of Leibnitz were dissipated by the multiplicity of his pursuits. He attempted more than he could finish; he designed more than he could execute; his imagination was too easily satisfied with a bold and rapid glance on the subject which he was impatient to leave; and he may be compared to those heroes whose empire has been lost in the ambition of universal conquest."[2]

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[1] Locke has fallen into a train of thought very similar to that of Bonnet, concerning the *Scale of Beings;* but has expressed himself with far greater caution;—stating it modestly as an inference deduced from an induction of particulars, not as the result of any abstract or metaphysical principle.—(See Locke's *Works*, Vol. III. p. 101.) In one instance, indeed, he avails himself of an allusion, which, at first sight, may appear to favour the extension of the mathematical *Law of Continuity* to the works of creation; but it is evident, from the context, that he meant this allusion merely as a popular illustration of a fact in Natural History; not as the rigorous enunciation of a theorem applicable alike to all truths, mathematical, physical, and moral. "It is a hard matter to say where sensible and rational begin, and where insensible and irrational end; and who is there quick-sighted enough to determine precisely, which is the lowest species of living things, and which is the first of those who have no life? Things, as far as we can observe, lessen and augment, as the quantity does in a *regular cone*, where, though there be a manifest odds betwixt the bigness of the diameter at a remote distance, yet the difference between the upper and under, where they touch one another, is hardly discernible."—(*Ibid.*)

See some Reflections on this speculation of Locke's in the *Spectator*, No. 519.

[2] See Note F F.

From some expressions which Leibnitz has occasionally dropped, I think it probable, that he himself became sensible, as he advanced in life, that his time might have been more profitably employed, had his studies been more confined in their aim. "If the whole earth (he has observed on one occasion) had continued to be of one language and of one speech, human life might be considered as extended beyond its present term, by the addition of all that part of it which is devoted to the acquisition of dead and foreign tongues. Many other branches of knowledge, too, may, in this respect, be classed with the languages; such as Positive Laws, Ceremonies, the Styles of Courts, and a great proportion of what is called *critical erudition.* The utility of all these arises merely from opinion; nor is there to be found, in the innumerable volumes that have been written to illustrate them, a hundredth part, which contains anything subservient to the happiness or improvement of mankind."

The most instructive lesson, however, to be drawn from the history of Leibnitz, is the incompetency of the most splendid gifts of the understanding, to advance essentially the interests either of Metaphysical or of Ethical Science, unless accompanied with that rare devotion to truth, which may be regarded, if not as the basis, at least as one of the most indispensable elements, of moral genius. The chief attraction to the study of philosophy, in *his* mind, seems to have been (what many French critics have considered as a chief source of the charms of the imitative arts) the pride of *conquering difficulties:* a feature of his character which he had probably in his own eye, when he remarked (not without some degree of conscious vanity), as a peculiarity in the turn or cast of his intellect, that to *him* "all difficult things were easy, and all easy things difficult."[1] Hence the disregard manifested in his writings to the simple and obvious conclusions of experience and common sense; and the perpetual effort to unriddle mysteries over which an impenetrable veil is drawn. "Scilicet sublime et erectum ingenium, pulchritudinem ac speciem excelsæ magnæque gloriæ vehementius quam caute appetebat." It is to be regretted, that the sequel of this fine eulogy does not equally apply to him. "Mox mitigavit ratio et ætas; *retinuitque, quod est difficillimum, et in sapientia modum.*"[2] How happily does this last expression characterise the temperate wisdom of Locke, when contrasted with that towering, but impotent ambition, which, in the Theories of Optimism and of Pre-established Harmony, seemed to realize the fabled revolt of the giants against the sovereignty of the gods!

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[1] A remarkable instance of this is mentioned by himself in one of his letters. "Annos natus tredecim una die trecentos versus hexametros effudi, sine elisione omnes, quod hoc fieri facile posse forte affirmassem." (Leib. *Op.* Tom. V. p. 304.) He also amused himself occasionally with writing verses in German and in French.

[2] May I presume to remark farther, that the native powers of Leibnitz's mind, astonishing and preternatural as they certainly were, seem sometimes oppressed and overlaid under the weight of his still more astonishing erudition? The influence of his scholastic reading is more peculiarly apparent in warping his judgment, and clouding his reason, on all questions connected with Metaphysical Theology.

After all, a similarity may be traced between these two great men in *one* intellectual weakness common to both; a facility in the admission of facts, stamped sufficiently (as we should *now* think) by their own intrinsic evidence, with the marks of incredibility. The observation has been often made with respect to Locke; but it would be difficult to find in Locke's writings, any thing so absurd as an account gravely transmitted by Leibnitz to the Abbé de St Pierre, and by him communicated to the Royal Academy of Sciences at Paris, of a dog who spoke.[3] No person liberally educated could, I believe, be found at present in any *Protestant* country of Christendom, capable of such credulity. By what causes so extraordinary a revolution in the minds of men has been effected, within the short space of a hundred years, I must not here stop to inquire. Much, I apprehend, must be ascribed to our enlarged knowledge of nature, and more particularly to those scientific voyages and travels which have annihilated so many of the prodigies which exercised the wonder and subdued the reason of our ancestors. But, in whatever manner the revolution is to be explained, there can be no doubt that this growing disposition to weigh scrupulously the *probability* of alleged *facts* against the faith due to the testimonies brought to attest them, and, even in some cases, against the apparent evidence of our own senses, enters largely and essentially into the composition of that philosophical *spirit* or temper, which so strongly distinguishes the eighteenth century from all those which preceded it.[4] It is no small consolation to reflect, that some important maxims of good sense have been thus familiarised to the most ordinary understandings, which, at so very recent a period, failed in producing their due effect on two of the most powerful minds in Europe.

On reviewing the foregoing paragraphs, I am almost tempted to retract part of what I have written, when I reflect on the benefits which the world has derived even from the *errors* of Leibnitz. It has been well and justly said, that "every *desideratum* is an imperfect discovery;" to which it may be added, that every new problem which is started, and still more every attempt, however abortive, towards its solution, strikes out a new path, which must sooner or later lead to the truth. If the problem be solvible, a solution will in due time be obtained: if insolvible, it will soon be abandoned as hopeless by general consent; and the legitimate field of scientific research will become more fertile, in proportion as a more accurate survey of its boundaries adapts it better to the limited resources of the cultivators.

In this point of view, what individual in modern times can be compared to Leibnitz! To how many of those researches, which still usefully employ the talents and industry of the learned, did he not point out and open the way! From how many more did he not warn the wise to withhold their curiosity, by his bold and fruitless attempts to burst the barriers of the invisible world!

The best *eloge* of Leibnitz is furnished by the literary history of the eighteenth century;—a history which, whoever takes the pains to compare with his works, and with his epistolary correspondence, will find reason to doubt whether, at the singular era when he appeared, he could have more accelerated the advancement of knowledge by the concentration of his studies, than he has actually done by the universality of his aims; and whether he does not afford one of the few instances to which the words of the poet may literally be applied:

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[1] "Sentio paucos esse mei characteris, et omnia facilia mihi difficilia, omnia contra difficilia mihi facilia esse."—Leib. *Op.* Tom. VI. p. 302.

[2] Tacitus, *Agric.*

[3] See Note G G.

[4] See Note H H.

> "Si non errasset, fecerat ille minus."

SECTION III.

Of the Metaphysical Speculations of Newton and Clarke. Digression with respect to the System of Spinoza.—Collins and Jonathan Edwards.—Anxiety of both to reconcile the Scheme of Necessity with Man's Moral Agency.—Departure of some later Necessitarians from their views.[2]

THE foregoing review of the philosophical writings of Locke and of Leibnitz naturally leads our attention, in the next place, to those of our illustrious countrymen Newton and Clarke; the former of whom has exhibited, in his *Principia* and *Optics*, the most perfect exemplifications which have yet appeared, of the cautious logic recommended by Bacon and Locke; while the other, in defending against the assaults of Leibnitz the metaphysical principles on which the Newtonian philosophy proceeds, has been led, at the same time, to vindicate the authority of various other truths, of still higher importance, and more general interest.

The chief subjects of dispute between Leibnitz and Clarke, so far as the principles of the Newtonian philosophy are concerned, have been long ago settled, to the entire satisfaction of the learned world. The *monads*, and the *plenum*, and the *pre-established harmony* of Leibnitz, already rank, in the public estimation, with the vortices of Descartes, and the plastic nature of Cudworth; while the theory of gravitation prevails everywhere over all opposition; and (as Mr Smith remarks) "has advanced to the acquisition of the most universal empire that was ever established in philosophy." On these points, therefore, I have only to refer my readers to the collection published by Dr Clarke, in 1717, of the controversial papers which passed between him and Leibnitz during the two preceding years;—a correspondence equally curious and instructive; and which, it is to be lamented, that the death of Leibnitz in 1716 prevented from being longer continued.[3]

Although Newton does not appear to have de-

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[1] See Note I I.

[2] In conformity to the plan announced in the preface to this *Dissertation*, I confine myself to those authors whose opinions have had a marked and general influence on the subsequent history of philosophy; passing over a multitude of other names well worthy to be recorded in the annals of metaphysical science. Among these, I shall only mention the name of Boyle, to whom the world is indebted, beside some very acute remarks and many fine illustrations of his own upon metaphysical questions of the highest moment, for the philosophical arguments in defence of religion, which have added so much lustre to the names of Derham and Bentley; and, far above both, to that of Clarke.* The *remarks* and *illustrations*, which I here refer to, are to be found in his *Inquiry into the Vulgar Notion of Nature*, and in his *Essay, inquiring whether, and how, a Naturalist should consider Final Causes.* Both of these tracts display powers which might have placed their author on a level with Descartes and Locke, had not his taste and inclination determined him more strongly to other pursuits. I am inclined to think, that neither of them is so well known as were to be wished. I do not even recollect to have seen it anywhere noticed, that some of the most striking and beautiful instances of design in the order of the material world, which occur in the Sermons preached at Boyle's *Lecture*, are borrowed from the works of the founder. †

Notwithstanding, however, these great merits, he has written too little on such abstract subjects to entitle him to a place among English metaphysicians; nor has he, like Newton, started any leading thoughts which have since given a new direction to the studies of metaphysical inquirers. From the slight specimens he has left, there is reason to conclude, that his mind was still more happily turned than that of Newton, for the prosecution of that branch of science to which their contemporary Locke was then beginning to invite the attention of the public.

[3] From a letter of Leibnitz to M. Remond de Montmort, it appears that he considered Newton, and not Clarke, as his

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* To the English reader it is unnecessary to observe, that I allude to the Sermons preached at the Lecture founded by the Honourable Robert Boyle.

† Those instances, more especially, which are drawn from the anatomical structure of animals, and the adaptation of their perceptive organs to the habits of life for which they are destined.

voted much of his time to Metaphysical researches, yet the general spirit of his physical investigations has had a great, though indirect, influence on the metaphysical studies of his successors. It is justly and profoundly remarked by Mr Hume, that "while Newton *seemed* to draw off the veil from some of the mysteries of nature, he showed, at the same time, the imperfections of the mechanical philosophy, and thereby restored her ultimate secrets to that obscurity in which they ever did, and ever will remain." In this way, his discoveries have co-operated powerfully with the reasonings of Locke in producing a general conviction of the inadequacy of our faculties to unriddle those sublime enigmas on which Descartes, Malebranche, and Leibnitz, had so recently wasted their strength, and which, in the ancient world, were regarded as the only fit objects of philosophical curiosity. It is chiefly too since the time of Newton, that the ontology and pneumatology of the dark ages have been abandoned for inquiries resting on the solid basis of experience and analogy; and that philosophers have felt themselves emboldened by his astonishing discoveries concerning the more distant parts of the material universe, to argue from the known to the unknown parts of the moral world. So completely has the prediction been verified which he himself hazarded, in the form of a query, at the end of his *Optics*, that "if natural philosophy should continue to be improved in its various branches, the bounds of moral philosophy would be enlarged also."

How far the peculiar cast of Newton's genius qualified him for prosecuting successfully the study of Mind, he has not afforded us sufficient *data* for judging; but such was the admiration with which his transcendent powers as a Mathematician and Natural Philosopher were universally regarded, that the slightest of his hints on other subjects have been eagerly seized upon as indisputable axioms, though sometimes with little other evidence in their favour but the supposed sanction of his authority.[1] The part of his works, however, which chiefly led me to connect his name with that of Clarke, is a passage in the *Scholium* annexed to his *Principia*,[2] which may be considered as the germ of the celebrated

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real antagonist in this controversy. "M. Clarke, ou plutôt M. Newton, dont M. Clarke soutient les dogmes, est en dispute avec moi sur la philosophie."—(Leib. *Op.* Tom. V. p. 33.) From another letter to the same correspondent we learn, that Leibnitz aimed at nothing less than the complete overthrow of the Newtonian philosophy; and that it was chiefly to his grand principle of the *sufficient reason* that he trusted for the accomplishment of this object. "J'ai reduit l'état de notre dispute à ce grand axiome, que *rien n'existe ou n'arrive sans qu'il y ait une raison suffisante, pourquoi il en est plutôt ainsi qu'autrement.* S'il continue à me le nier, où en sera sa sincerité? S'il me l'accorde, adieu le vuide, les atomes, *et toute la philosophie de M. Newton.*"—*(Ibid.)* See also a letter from Leibnitz to M. des Maizeaux in the same volume of his works, p. 39.

[1] Witness Hartley's *Physiological Theory of the Mind*, founded on a query in Newton's *Optics*; and a long list of theories in medicine, grafted on a hint thrown out in the same query, in the form of a modest conjecture.

[2] This *Scholium*, it is to be observed, first appeared at the end of the second edition of the *Principia*, printed at Cambridge in 1713. The former edition, published at London in 1687, has no *Scholium* annexed to it. From a passage, however, in a letter of Newton's to Dr Bentley (dated 1692), it seems probable, that as far back, at least, as that period, he had thoughts of attempting a proof *a priori* of the existence of God. After some new illustrations, drawn from his own discoveries, of the common argument from *final causes*, he thus concludes: "There is yet *another* argument for a Deity, which I take to be a very strong one; but, till the principles on which it is grounded are better received, I think it more advisable to let it sleep."—*(Four Letters from Sir I. Newton to Dr Bentley*, p. 11. London, Dodsley, 1756.)

It appears from this passage, that Newton had no intention, like his predecessor Descartes, to supersede, by any new argument of his own for the existence of God, the common one drawn from the consideration of *final causes*; and, therefore, nothing could be more uncandid than the following sarcasm pointed by Pope at the laudable attempts of his two countrymen to *add* to the evidence of this conclusion, by deducing it from *other* principles:

"Let others creep by timid steps and slow,
On plain experience lay foundations low,
By common sense to common knowledge bred,
And last to Nature's cause thro' Nature led:
We nobly take the high *priori*-road,
And reason downwards till we doubt of God."

That Pope had Clarke in his eye when he wrote these lines, will not be doubted by those who recollect the various other occasions in which he has stepped out of his way, to vent an impotent spleen against this excellent person.

"Let Clarke live half his life the poor's support,
But let him live the other half at court."

And again:

"Even in an ornament its place remark;
Nor in a hermitage set Dr Clarke:"

in which last couplet there is a manifest allusion to the bust of Clarke, placed in a hermitage by Queen Caroline, together with those of Newton, Boyle, Locke, and Wollaston. See some fine verses on these busts in a poem called the *Grotto*, by Matthew Green.

argument *a priori* for the existence of God, which is commonly, though, I apprehend, not justly, regarded as the most important of all Clarke's contributions to Metaphysical Philosophy. I shall quote the passage in Newton's own words, to the oracular conciseness of which no English version can do justice.

"Æternus est et infinitus, omnipotens et omnisciens; id est, durat ab æterno in æternum, et adest ab infinito in infinitum. . . . . Non est æternitas et infinitas, sed æternus et infinitus; non est duratio et spatium, sed durat et adest. Durat semper et adest ubique, et existendo semper et ubique durationem et spatium constituit."[1] Proceeding on these principles, Dr Clarke argued, that, as immensity and eternity (which force themselves irresistibly on our belief as *necessary* existences, or, in other words, as existences of which the annihilation is impossible) are not *substances*, but *attributes*, the immense and eternal Being, whose attributes they are, must exist of necessity also. The existence of God, therefore, according to Clarke, is a truth that follows with demonstrative evidence from those conceptions of space and time which are inseparable from the human mind. . . . . "These (says Dr Reid) are the speculations of men of superior genius; but whether they be as solid as they are sublime, or whether they be the wanderings of imagination in a region beyond the limits of the human understanding, I am at a loss to determine." After this candid acknowledgment from Dr Reid, I need not be ashamed to confess my own doubts and difficulties on the same question.[2]

But although the argument, as stated by Clarke, does not carry complete satisfaction to my mind, I think it must be granted that there is something peculiarly wonderful and overwhelming in those conceptions of immensity and eternity, which it is not less impossible to banish from our thoughts, than the consciousness of our own existence. Nay, further, I think that these conceptions are very intimately connected with the fundamental principles of Natural Religion. For when once we have established, from the evidences of design everywhere manifested around us, the existence of an intelligent and powerful *cause*, we are unavoidably led to apply to this *cause* our conceptions of *immensity* and *eternity*, and to conceive Him as filling the infinite extent of both with his presence and with his power. Hence we associate with the idea of God those awful impressions which are naturally produced by the idea of infinite space, and perhaps still more by the idea of endless duration. Nor is this all. It is from the immensity of space that the notion of infinity is originally derived; and it is hence that we transfer the expression, by a sort of metaphor, to other subjects. When we speak, therefore, of *infinite* power, wisdom, and goodness, our notions, if not wholly borrowed from space, are at least greatly aided by this analogy; so that the conceptions of Immensity and Eternity, if they do not of themselves *demonstrate* the existence of God, yet necessarily enter into the ideas we form of his nature and attributes.

To these various considerations it may be added that the notion of *necessary existence* which we derive from the contemplation of Space and of Time, renders the same notion, when applied to the Supreme Being, much more easy to be apprehended than it would otherwise be.

It is not, therefore, surprising, that Newton and Clarke should have fallen into that train of thought which encouraged them to attempt a demonstration of the being of God from our conceptions of Immensity and Eternity; and still less is it to be wondered at, that, in pursuing this lofty argument, they should have soared into regions where they were lost in the clouds.

I have said above, that Clarke's demonstration seems to have been suggested to him by a passage in Newton's *Scholium*. It is, however, more than probable that he had himself struck into a path very nearly approaching to it, at a much earlier period of his life. The following anecdote of his childhood, related, upon his own authority, by his learned and authentic, though, in many respects, weak and visionary biographer (Whiston), exhibits an interesting example of an anomalous development of the powers of reflection and abstraction, at an age when, in ordinary cases, the attention is wholly engrossed with sensible objects. Such an inversion of the common process of nature in unfolding our different faculties, is perhaps one of the rarest phenomena in the intellectual world; and, wherever it occurs, may be regarded as strongly symptomatic of something peculiar and decided in the philosophical character of the individual.

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[1] Thus translated by Dr Clarke: "God is eternal and infinite, omnipotent and omniscient; that is, he endures from everlasting to everlasting, and is present from infinity to infinity. He is not eternity or infinity, but eternal and infinite. He is not duration or space, but he endures and is present. He endures always, and is present everywhere, and by existing always and everywhere, constitutes duration and space."—(See CLARKE'S *Fourth Reply to Leibnitz.*)

[2] An argument substantially the same with this for the existence of God, is hinted at very distinctly by Cudworth, *Intellect. System*, Chap. V. sect. 3. 4. Also by Dr Henry More, *Enchir. Metaph.* Cap. 8. sect. 8. See MOSHEIM'S *Transl. of Cudworth*, Tom. II. p. 356.

" One of his parents," says Whiston, " asked him when he was very young, Whether God could do every thing? He answered, Yes! He was asked again, Whether God could tell a lie? He answered, No! And he understood the question to suppose, that this was the only thing that God could not do; nor durst he say, so young was he then, that he thought there was any thing else which God could not do; while yet, well he remembered, that he had, *even then, a clear conviction in his own mind, that there was one thing which God could not do;—that he could not annihilate that space which was in the room where they were.*"[1]

With this early and deep impression on his mind, it is easy to conceive how Newton's *Scholium* should have encouraged him to resume the musings of his *boyish days*, concerning the necessary existence of space; and to trace, as far as he could, its connection with the principles of Natural Theology. But the above anecdote affords a proof how strongly his habits of thought had long before predisposed him for the prosecution of a metaphysical idea, precisely the same with that on which this Scholium proceeds.

It would be superfluous to dwell longer on the history of these speculations, which, whatever value they may possess in the opinion of persons accustomed to deep and abstract reasoning, are certainly not well adapted to ordinary or to uncultivated understandings. This consideration furnishes, of itself, no slight presumption, that they were not intended to be the *media* by which the bulk of mankind were to be led to the knowledge of truths so essential to human happiness; and, accordingly, it was on this very ground, that Bishop Butler, and Dr Francis Hutcheson, were induced to strike into a different and more popular path for establish-

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[1] The question concerning the necessary existence of Space and of Time formed one of the principal subjects of discussion between Clarke and Leibnitz. According to the former, space and time are, both of them, infinite, immutable, and indestructible. According to his antagonist, " space is nothing but the order of things co-existing," and " time nothing but the order of things successive !" The notion of real absolute Space, in particular, he pronounces to be *a mere chimera and superficial imagination ;* classing it with those prejudices which Bacon called *idola tribus*.—(See his 4th *Paper*, § 14.)

It has always appeared to me a thing quite inexplicable, that the great majority of philosophers, both in Germany and in France, have, on the above question, decided in favour of Leibnitz. Even D'Alembert himself, who, on most metaphysical points, reasons so justly and so profoundly, has, in this instance, been carried along by the prevailing opinion (or, perhaps, it would be more correct to say, by the fashionable phraseology) among his countrymen. " Y auroit-il un espace, s'il n'y avoit point de corps, et une durée s'il n'y avoit rien? Ces questions viennent, ce me semble, de ce qu'on suppose au temps et à l'espace plus de réalité qu'ils n'en ont . . . . . Les enfants, qui disent que le vuide n'est rien, ont raison parce qu'ils s'en tiennent au simples notions du sens commun:* et les philosophes qui veulent réaliser le vuide se perdent dans leurs spéculations: le vuide a été enfanté par les abstractions, et voilà l'abus d'une méthode si utile à bien des égards. *S'il n'y avoit point de corps et de succession, l'espace et le temps seroient possibles, mais ils n'existeroient pas.*"—(*Mélanges*, &c. T. V. § xvi.) Bailly, a writer by no means partial to D'Alembert, quotes, with entire approbation, the foregoing observations; subjoining to them, in the following terms, his own judgment on the merits of this branch of the controversy between Clarke and Leibnitz. " La notion du temps et de l'espace, est un des points sur lesquels Leibnitz a combattu contre Clarke ; mais il nous semble que l'Anglois n'a rien opposé de satisfaisant aux raisons de Leibnitz."—(*Eloge de Leibnitz.*)

As for the point here in dispute, I must own, that it does not seem to me a fit subject for argument; inasmuch as I cannot even form a conception of the proposition contended for by Leibnitz. The light in which the question struck Clarke in his childhood, is the same in which I am still disposed to view it; or rather, I should say, is the light in which I must ever view it, while the frame of my understanding continues unaltered. Of what *data* is human reason possessed, from which it is entitled to argue in opposition to truths, the contrary of which it is impossible not only to prove, but to express in terms comprehensible by our faculties?

For some remarks on the scholastic controversies concerning *space* and *time*, see the First Part of this *Dissertation*, Note I. See also Locke's *Essay*, Book ii. Chap. 13. §§ 16, 17, 18.

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* I quote the sequel of this passage on the authority of Bailly (see his *Eloge on Leibnitz*), for it is not to be found in the copy of the *Mélanges* before me printed at Amsterdam in 1767.

ing the fundamental principles of religion and morality. Both of these writers appear to have communicated, in very early youth, their doubts and objections to Dr Clarke; and to have had, even then, a glimpse of those inquiries by which they were afterwards to give so new and so fortunate a direction to the ethical studies of their countrymen. It is sufficient here to remark this circumstance as an important step in the progress of Moral Philosophy. The farther illustration of it properly belongs to another part of this discourse.

The chief glory of Clarke, as a metaphysical author, is due to the boldness and ability with which he placed himself in the breach against the Necessitarians and Fatalists of his times. With a mind far inferior to that of Locke, in comprehensiveness, in originality, and in fertility of invention, he was nevertheless the more wary and skilful disputant of the two, possessing, in a singular degree, that reach of thought in grasping remote consequences, which effectually saved him from those rash concessions into which Locke was frequently betrayed by the greater warmth of his temperament, and vivacity of his fancy. This logical foresight (the natural result of his habits of mathematical study) rendered him peculiarly fit to contend with adversaries, eager and qualified to take advantage of every vulnerable point in his doctrines; but it gave, at the same time, to his style a tameness, and monotony, and want of colouring, which never appear in the easy and spirited, though often unfinished and unequal, sketches of Locke. Voltaire has somewhere said of him, that he was a mere reasoning machine *(un moulin à raisonnement)*, and the expression (though doubtless much too unqualified) possesses a merit, in point of just discrimination, of which Voltaire was probably not fully aware.[1]

I have already taken notice of Clarke's defence of moral liberty in opposition to Leibnitz; but soon after this controversy was brought to a conclusion by the death of his antagonist, he had to resume the same argument, in reply to his countryman, Anthony Collins; who, following the footsteps of Hobbes, with logical talents not inferior to those of his master, and with a weight of personal character in his favour, to which his master had no pretensions,[1] gave to the cause which he so warmly espoused, a degree of credit among sober and serious inquirers, which it had never before possessed in England. I have reserved, therefore, for this place, the few general reflections which I have to offer on this endless subject of controversy. In stating these, I shall be the less anxious to condense my thoughts, as I do not mean to return to the discussion in the sequel of this historical sketch. Indeed, I do not know of anything that has been advanced by later writers, in support of the scheme of necessity, of which the germ is not to be found in the inquiry of Collins.

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[1] In the extent of his learning, the correctness of his taste, and the depth of his scientific acquirements, Clarke possessed indisputable advantages over Locke; with which advantages he combined another not less important, the systematical steadiness with which his easy fortune and unbroken leisure enabled him to pursue his favourite speculations through the whole course of his life.

On the subject of Free-will, Locke is more indistinct, undecided, and inconsistent, than might have been expected from his powerful mind, when directed to so important a question. This was probably owing to his own strong feelings in favour of man's moral liberty, struggling with the deep impression left on his philosophical creed by the writings of Hobbes, and with his deference for the talents of his own intimate friend, Anthony Collins.* That Locke conceived himself to be an advocate for *free-will*, appears indisputably from many expressions in his Chapter on *Power;* and yet, in that very chapter, he has made various concessions to his adversaries, in which he seems to yield all that was contended for by Hobbes and Collins: And, accordingly, he is ranked, with some appearance of truth, by Priestley, with those who, while they opposed verbally the scheme of necessity, have adopted it substantially, without being aware of their mistake.

In one of Locke's letters to Mr Molyneux, he has stated, in the strongest possible terms, his conviction of man's free agency; resting this conviction entirely on our indisputable consciousness of *the fact.* This declaration of Locke I consider as well worthy of attention in the argument about Free Will; for, although in questions of pure speculation, the authority of great names is entitled to no weight, excepting in so far as it is supported by solid reasonings, the case is otherwise with *facts* relating to the phenomena of the human mind. The patient attention with which Mr Locke had studied these very nice phenomena during the course of a long life, gives to the results of his metaphysical experience a value of the same sort, but much greater in degree, with that which we attach to a delicate experiment in chemistry, when vouched by a Black or a Davy. The ultimate appeal, after all, must be made by every person to his own consciousness; but when we have the experience of Locke on the one hand, and that of Priestley and Belsham on the other, the contrast is surely sufficient to induce every cautious inquirer to re-examine his feelings before he allows himself to listen to the statements of the latter in preference to that of the former.

For the information of some of my readers, it may be proper to mention that it has of late become fashionable among a certain class of metaphysicians, boldly to assert, that the evidence of *their* consciousness is decidedly in favour of the scheme of necessity.

But to return to Mr Locke. The only consideration on this subject which seems to have staggered him, was the difficulty of reconciling this opinion with the prescience of God. As to this theological difficulty, I have nothing to say at present. The only question which I consider as of any consequence, is the matter of fact; and, on this point, nothing can be more explicit and satisfactory than the words of Locke. In examining these, the attentive reader will be satisfied, that Locke's declaration is not (as Priestley asserts) in favour of the Liberty of Spontaneity, but in favour of the Liberty of Indifference; for as to the former, there seems to be no difficulty in reconciling it with the prescience of God. "I own (says Mr Locke) freely to you the weakness of my understanding, that though it be unquestionable that there is omnipotence and omniscience in God our Maker, and though *I cannot have a clearer perception of anything than that I am free;* yet I cannot make freedom in man consistent with omnipotence and omniscience in God, though I am as fully persuaded of both as of any truth I most firmly assent to; and therefore I have long since given off the consideration of that question; resolving all into this short conclusion, that, *if it be possible for God to make a free agent, then man is free, though I see not the way of it.*"

* See Note K K.

In order to enter completely into the motives which induced Clarke to take so zealous and so prominent a part in the dispute about Free Will, it is necessary to look back to the system of Spinoza; an author, with whose peculiar opinions I have hitherto avoided to distract my readers' attention. At the time when he wrote, he does not appear to have made many proselytes; the extravagant and alarming consequences in which his system terminated, serving with most persons as a sufficient antidote against it. Clarke was probably the first who perceived distinctly the logical accuracy of his reasoning; and that, if the principles were admitted, it was impossible to resist the conclusions deduced from them.[2] It seems to have been the object both of Leibnitz and of Collins, to obviate the force of this indirect argument against the scheme of necessity, by attempting to reconcile it with the moral agency of man; a task which, I think, it must be allowed, was much less ably and plausibly executed by the former than by the latter. Convinced, on the other hand, that Spinoza had reasoned from his premises much more rigorously than either Collins or Leibnitz, Clarke bent the whole force of his mind to demonstrate that these premises were false; and, at the same time, to put incautious reasoners on their guard against the seducing sophistry of his antagonists, by showing, that there was no medium between admitting the free-agency of man, and of acquiescing in all the monstrous absurdities which the creed of Spinoza involves.

Spinoza,[3] it may be proper to mention, was an Amsterdam Jew of Portuguese extraction, who (with a view probably to gain a more favourable reception to his philosophical dogmas) withdrew himself from the sect in which he had been educated, and afterwards appears to have lived chiefly in the society of Christians;[4] without, however, making any public profession of the Christian faith, or even submitting to the ceremony of baptism. In his philosophical creed, he at first embraced the system of Descartes, and began his literary career with a work entitled, *Renati Descartes Principiorum Philosophiæ, Pars Prima et Secunda, More Geometrico Demonstratæ*, 1663. It was, however, in little else than his physical principles that he agreed with Descartes; for no two philosophers ever differed more widely in their metaphysical and theological tenets. Fontenelle characterises his system as a "Cartesianism pushed to extravagance" *(une Cartésianisme outrée)*; an expression which, although far from conveying a just or adequate idea of the whole spirit of his doctrines, applies very happily to his boldness and pertinacity in following out his avowed principles to the most paradoxical consequences which he conceived them to involve. The reputation of his writings, accordingly, has fallen entirely (excepting perhaps in Germany and in Holland) with the philosophy on which they were grafted; although some of the most obnoxious opinions contained in them are still, from time to time, obtruded on the world, under the disguise of a new form, and of a phraseology less revolting to modern taste.[1]

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[1] In speaking disrespectfully of the personal character of Hobbes, I allude to the base servility of his political principles, and to the suppleness with which he adapted them to the opposite interests of the three successive governments under which his literary life was spent. To his private virtues the most honourable testimony has been borne, both by his friends and by his enemies.

[2] Dr Reid's opinion on this point coincides exactly with that of Clarke. See his Essays on the *Active Powers of Man*, (p. 289, 4to. Edition), where he pronounces the system of Spinoza to be " the genuine, and the most tenable system of necessity."

[3] Born 1632, died 1677. It is observed by Bayle, that " although Spinoza was the first who reduced Atheism to a system, and formed it into a body of doctrine, connected according to the method of geometricians, yet, in other respects, his opinion is not new, the substance of it being the same with that of several other philosophers, both ancient and modern, European and Eastern."—See his Dict. art. *Spinoza*, and the authorities in Note S.

It is asserted by a late German writer, that " Spinoza has been little heard of in England, and not at all in France, and that he has been zealously defended and attacked by Germans alone." The same writer informs us, that " the philosophy of Leibnitz has been little studied in France, and not at all in England."—(*Lectures on the History of Literature*, by FRED SCHLEGEL. English Transl. published at Edin. 1818. Vol. II. p. 243.)

Is it possible that an author who pronounces so dogmatically upon the philosophy of England, should never have heard the name of Dr Clarke?

[4] The Synagogue were so indignant at his apostacy, that they pronounced against him their *highest* sentence of excommunication called *Schammata*. The form of the sentence may be found in the Treatise of Selden, *De Jure Naturæ et Gentium*, Lib. IV. c. 7. It is a document of some curiosity, and will scarcely suffer by a comparison with the Popish form of excommunication recorded by Sterne. For some farther particulars with respect to Spinoza see Note LL.

In no part of Spinoza's works has he avowed himself an atheist; but it will not be disputed, by those who comprehend the drift of his reasonings, that, in point of practical tendency, Atheism and Spinozism are one and the same. In this respect, we may apply to Spinoza (and I may add to Vanini also) what Cicero has said of Epicurus, *Verbis reliquit Deos, re sustulit*;—a remark which coincides exactly with an expression of Newton's in the *Scholium* at the end of the *Principia*: "DEUS sine dominio, providentia, et causis finalibus, nihil aliud est quam FATUM et NATURA."[2]

Among other doctrines of natural and revealed religion, which Spinoza affected to embrace, was that of the Divine Omnipresence; a doctrine which, combined with the Plenum of Descartes, led him, by a short and plausible process of reasoning, to the revival of the old theory which represented God as *the soul of the world*; or rather to that identification of God and of the material universe, which I take to be still more agreeable to the idea of Spinoza.[3] I am particularly anxious to direct the attention of my readers to this part of his system, as I conceive it to be at present very generally misrepre-

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[1] "On vient de proposer à l'Académie de Berlin, pour sujet de concours: "Quels sont les points de contact du Cartésianisme et du système de Spinoza?"—*(Récherches Philosophiques*, par M. DE RONALD, 1818.)

[2] One of the most elaborate and acute refutations of Spinozism which has yet appeared is to be found in Bayle's Dictionary, where it is described as "the most monstrous scheme imaginable, and the most diametrically opposite to the clearest notions of the mind."—The same author affirms, that "it has been fully overthrown even by the weakest of its adversaries."—"It does not, indeed, appear possible" (as Mr Maclaurin has observed) "to invent another system equally absurd; amounting (as it does in fact) to this proposition, that there is but one substance in the universe, endowed with infinite attributes (particularly infinite extension and cogitation), which produces all other things necessarily as its own modifications, and which alone is, in all events, both physical and moral, at once cause and effect, agent and patient.—*View of Newton's Discoveries*, Book I. Chap. 4.

[3] Spinoza supposes that there are in God two eternal properties, thought and extension; and as he held, with Descartes, that extension is the essence of matter, he must necessarily have conceived *materiality* to be an essential attribute of God. "Per Corpus intelligo modum, qui Dei essentiam quatenus ut res extensa consideratur, certo et determinato modo exprimit."—*(Ethica ordine Geometrico Demonstrata*, Pars 2. Defin. 1. See also *Ethic.* Pars 1. Prop. 14.) With respect to the other attributes of God, he held, that God is the *cause* of all things; but that he acts, not from choice, but from necessity; and of consequence, that he is the involuntary author of all the good and evil, virtue and vice, which are exhibited in human life. "Res nullo alio modo, neque alio ordine a Deo produci potuerunt, quam productæ sunt."—*Ibid.* Pars 1. Prop. 33.) In one of his letters to Mr Oldenburgh (Letter 21), he acknowledges, that his ideas of God and of nature were very different from those entertained by *modern* Christians; adding by way of explanation, "Deum rerum omnium causam immanentem, non vero transeuntem statuo;"—an expression to which I can annex no other meaning but this, that God is inseparably and essentially united with his works, and that they form together but one being.

The diversity of opinions entertained concerning the nature of Spinozism has been chiefly owing to this, that some have formed their notions of it from the books which Spinoza published during his life, and others from his posthumous remains. It is in the last alone (particularly in his *Ethics*) that his system is to be seen completely unveiled and undisguised. In the former, and also in the letters addressed to his friends, he occasionally accommodates himself, with a very temporising spirit, to what he considered as the prejudices of the world. In proof of this, see his *Tractatus Theologico-Politicus*, and his epistolary correspondence, *passim*; above all, his letter to a young friend who had apostatised from Protestantism to the Catholic Church. The letter is addressed, "Nobilissimo Juveni, *Alberto Burgh*."—(SPIN. *Op.* T. II. p. 695.)

The edition of Spinoza's works to which my references are made, is the complete and very accurate one published at Jena in 1802, by Henr. Eberh. Gottlob Paulus, who styles himself Doctor and Professor of Theology.

This learned divine is at no pains to conceal his admiration of the character as well as talents of his author; nor does he seem to have much to object to the system of Spinozism, as explained in his posthumous work upon Ethics;—a work which, the editor admits, contains the only genuine exposition of Spinoza's creed. "Sedes systematis quod sibi condidit in ethica est."—*(Præf. Iteratæ Editionis*, p. ix.) In what manner all this was reconciled in his theological lectures with the doctrines either of natural or of revealed religion, it is not very easy to imagine. Perhaps he only affords a new example of what sented, or, at least, very generally misunderstood; a thing not to be wondered at, considering the total neglect into which his works have long fallen. It is only in this way I can account for the frequent use which has most unfairly been made of the term *Spinozism* to stigmatise and discredit some doctrines, or rather some modes of speaking, which have been sanctioned, not only by the wisest of the ancients, but by the highest names in English philosophy and literature; and which, whether right or wrong, will be found, on a careful examination and comparison, not to have the most distant affinity to the absurd creed with which they have been confounded. I am afraid that Pope, in the following lines of the *Dunciad*, suffered himself so far to be misled by the malignity of Warburton, as to aim a secret stab at Newton and Clarke, by associating their figurative, and not altogether unexceptionable language, concerning *space* (when they called it the *sensorium* of the Deity), with the opinion of Spinoza, as I have just explained it.[1]

> " Thrust some Mechanic Cause into His place,
> Or bind in matter, or *diffuse in space.*"

Dr Clarke long ago remarked, that " Believing too much and too little have commonly the luck to meet together, like two things moving contrary ways in the same circle."—*(Third Letter to Dodwell.)*

A late German writer, who, in his own opinions, has certainly no leaning towards Spinozism, has yet spoken of the moral tendency of Spinoza's writings, in terms of the warmest praise. " The morality of Spinoza (says M. Fred. Schlegel) is not indeed that of the Bible, for he himself was no Christian, but it is still a pure and noble morality, resembling that of the ancient Stoics, perhaps possessing considerable advantages over that system. That which makes him strong when opposed to adversaries who do not understand or feel his depth, or who unconsciously have fallen into errors not much different from his, is not merely the scientific clearness and decision of his intellect, but in a much higher degree the openheartedness, strong feeling, and conviction, with which all that he says seems to gush from his heart and soul."—*(Lect. of* FRED. SCHLEGEL, Eng. Transl. Vol. II. p. 244.) The rest of the passage, which contains a sort of apology for the system of Spinoza, is still more curious.

Although it is with the metaphysical tenets of Spinoza alone that we are immediately concerned at present, it is not altogether foreign to my purpose to observe, that he had also speculated much about the principles of government; and that the coincidence of his opinions with those of Hobbes, on this last subject, was not less remarkable than the similarity of their views on the most important questions of metaphysics and ethics. Unconnected as these different branches of knowledge may at first appear, the theories of Spinoza and of Hobbes concerning *all* of them, formed parts of one and the same system; the whole terminating ultimately in the maxim with which, according to Plutarch, Anaxarchus consoled Alexander after the murder of Clytus: Πᾶν τὸ πραχθὲν ἀπὸ τοῦ κρατοῦντος δίκαιον εἶναι. Even in discussing the question about Liberty and Necessity, Hobbes cannot help glancing at this political corollary. " The *power* of God alone is a sufficient *justification* of any action he doth."... " That which he doth is made just by his doing it."... " Power irresistible justifies *all* actions really and properly, in whomsoever it be found."—*(Of Liberty and Necessity*, addressed to the Lord Marquis of Newcastle.) Spinoza has expressed himself exactly to the same purpose.—(See his *Tractatus Politicus*, Cap. 2. §§ 3, 4.) So steadily, indeed, is this practical application of their abstract principles kept in view by both these writers, that not one generous feeling is ever suffered to escape the pen of either in favour of the rights, the liberties, or the improvement of their species.

The close affinity between those abstract thories which tend to degrade human nature, and that accommodating morality which prepares the minds of men for receiving passively the yoke of slavery, although too little attended to by the writers of literary history, has not been overlooked by those deeper politicians who are disposed (as has been alleged of the first of the Cæsars) to consider their fellow-creatures " but as rubbish in the way of their ambition, or tools to be employed in removing it." This practical tendency of the Epicurean philosophy is remarked by one of the wisest of the Roman statesmen; and we learn from the same high authority, how fashionable this philosophy was in the higher circles of his countrymen, at that disastrous period which immediately preceded the ruin of the Republic. " Nunquam audivi in Epicuri schola, Lycurgum, Solonem, Miltiadem, Themistoclem, Epaminondam, nominari; qui in ore sunt cæterorum omnium philosophorum."—*(De Fin.* Lib. ii. c. 21.) " Nec tamen Epicuri licet oblivisci, si cupiam; cujus imaginem non modo in tabulis nostri familiares, sed etiam in poculis, et annulis habent."—*(Ibid.* Lib. v. c. 1.)

The prevalence of Hobbism at the court of Charles II. (a fact acknowledged by Clarendon himself) is but one of the many instances which might be quoted from modern times in confirmation of these remarks.

The practical tendency of such doctrines as would pave the way to universal scepticism, by holding up to ridicule the extravagancies and inconsistencies of the learned, is precisely similar. We are told by Tacitus (*Annal.* Lib. 14), that Nero was accustomed, at the close of a banquet, to summon a party of philosophers, that he might amuse himself with listening to the endless diversity and discordancy of their respective systems: nor were there wanting philosophers at Rome, the same historian adds, who were flattered to be thus exhibited as a spectacle at the table of the Emperor. What a deep and instructive moral is conveyed by this anecdote! and what a contrast does it afford to the sentiment of one of Nero's successors, who was himself a philosopher in the best sense of the word, and whose reign furnishes some of the fairest pages in the annals of the human race! " I search for truth (says Marcus Antoninus), by which no person has ever been injured." Ζηλῶ γὰρ τὴν ἀλήθειαν, ὑφ᾽ ἧς οὐδεὶς πώποτε ἐβλάβη.

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[1] Warburton, indeed, always *professes* great respect for Newton; but of his hostility to Clarke it is unnecessary to produce any other proof than his note on the following line of the Dunciad:

> " Where Tindal dictates, and Silenus snores."—B. iv. *l.* 492.

May I venture to add, that the noted line of the *Essay on Man*,

> " And showed a Newton as we show an ape,"

could not possibly have been written by any person impressed with a due veneration for this glory of his species?

How little was it suspected by the poet, when this sarcasm escaped him, that the charge of Spinozism and Pantheism was afterwards to be brought against himself, for the sublimest passage to be found in his writings!

> " All are but parts of one stupendous whole,
> Whose body Nature is, and God the soul.
>
> * * * * *
>
> Lives through all Life, *extends through all extent*,
> *Spreads undivided*, operates unspent."[1]

Bayle was, I think, the writer who first led the way to this misapplication of the term *Spinozism;* and his object in doing so was plainly to destroy the effect of the most refined and philosophical conceptions of the Deity which were ever formed by the unassisted power of human reason.

> " Estne Dei sedes nisi terra, et pontus, et aër,
> Et cœlum, et virtus? Superos quid quærimus ultra?
> Jupiter est quodcumque vides, quocumque moveris."

> " Is there a place that God would choose to love
> Beyond this earth, the seas, yon Heaven above,
> And virtuous minds, the noblest throne for Jove;
> Why seek we farther then? Behold around,
> How all thou seest does with the God abound,
> Jove is alike to all, and always to be found."
>
> ROWE'S *Lucan.*

Who but Bayle, could have thought of extracting anything like Spinozism from such verses as these!

On a subject so infinitely disproportioned to our faculties, it is vain to expect language which will bear a logical and captious examination. Even the Sacred Writers themselves are forced to adapt their phraseology to the comprehension of those to whom it is addressed, and frequently borrow the figurative diction of poetry to convey ideas which must be interpreted, not according to the letter, but the spirit of the passage. It is thus that thunder is called the voice of God; the wind, His breath; and the tempest, the blast of His nostrils. Not attending to this circumstance, or rather not choosing to direct to it the attention of his readers, Spinoza has laid hold of the well known expression of St Paul, that " in God we live, and move, and have our being," as a proof that the ideas of the apostle, concerning the Divine Nature, were pretty much the same with his own; a consideration which, if duly weighed, might have protected some of the passages above quoted from the uncharitable criticisms to which they have frequently been exposed.[2]

To return, however, to Collins, from whose controversy with Clarke I was insensibly led aside into this short digression about Spinoza:

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[1] This passage, as Warton has remarked, bears a very striking analogy to a noble one in the old Orphic verses quoted in the treatise Περὶ κόσμȣ, ascribed to Aristotle; and it is not a little curious, that the same ideas occur in some specimens of *Hindoo* poetry, translated by Sir W. Jones; more particularly in the Hymn to *Narrayna*, or the Spirit of God, taken, as he informs us, from the writings of their ancient authors:

> Omniscient Spirit, whose all-ruling power
> Bids from each sense bright emanations beam;
> Glows in the rainbow, sparkles in the stream,
> &c. &c.

[2] Mr Gibbon, in commenting upon the celebrated lines of Virgil,

> " Spiritus intus alit, totamque infusa per artus,
> " Mens agitat molem, et magno se corpore miscet,"

observes, that " the mind which is INFUSED into the different parts of matter, and which MINGLES ITSELF with the mighty mass, scarcely retains any property of a spiritual substance, and bears too near an affinity to the principles which the impious Spinoza revived rather than invented." He adds, however, that " the poverty of human language, and the obscurity of human ideas, make it difficult to speak worthily of the GREAT FIRST CAUSE; and that our most religious poets (particularly Pope and Thomson), in striving to express the presence and energy of the Deity in every part of the universe, deviate unwarily into images which require a favourable construction. But these writers (he candidly remarks) deserve that favour, by the sublime manner in which they celebrate the Great Father of the universe, and by those effusions of love and gratitude which are inconsistent with the materialist's system."—(*Misc. Works*, Vol. II. pp. 509, 510.)

May I be permitted here to remark, that it is not only *difficult* but *impossible* to speak of the omnipresence and omnipotence of God, without deviating into such images?

With the doctrine of the *Anima Mundi*, some philosophers, both ancient and modern, have connected another theory, according to which the souls of men are portions of the Supreme Being, with whom they are re-united at death, and in whom they are finally absorbed and lost. To assist the imagination in conceiving this theory, death has been compared to the breaking of a phial of water, immersed in the ocean. It is needless to say, that this incomprehensible jargon has no *necessary* connection with the doctrine which represents God as the soul of the world, and that it would have been loudly disclaimed, not only by Pope and Thomson, but by Epictetus, Antoninus, and all the wisest and soberest of the Stoical school. Whatever objections, therefore, may be made to this doctrine, let not its supposed *consequences* be charged upon any but those who may expressly avow them. On such a subject, as Gibbon has well remarked, " we should be slow to suspect, and still slower to condemn."—(*Ibid.* p. 510.)

Sir William Jones mentions a very curious modification of this theory of *absorption*, as one of the doctrines of the *Vedanta* school. " The Vedanta school represent *Elysian* happiness as a total absorption, *though not such as to destroy consciousness*, in the Divine Essence."—*(Dissertation on the Gods of Greece, Italy, and India.)*

I have already said, that it seems to have been the aim of Collins to vindicate the doctrine of Necessity from the reproach brought on it by its supposed alliance with Spinozism; and to retort upon the partizans of free-will the charges of favouring atheism and immorality. In proof of this I have only to quote the account given by the author himself, of the plan of his work:

"Too much care cannot be taken to prevent being misunderstood and prejudged, in handling questions of such nice speculation as those of Liberty and Necessity; and, therefore, though I might in justice expect to be read before any judgment be passed on me, I think it proper to premise the following observations:

"1. *First*, Though I deny *liberty* in a certain meaning of that word, yet I contend for *liberty*, as it signifies *a power in man to do as he wills or pleases.*

"2. *Secondly*, When I affirm *necessity*, I contend only for *moral necessity;* meaning thereby, that man, who is an intelligent and sensible being, is determined by his reason and his senses; and I deny man to be subject to such necessity as is in clocks, watches, and such other beings, which, for want of sensation and intelligence, are subject to an absolute, physical, or mechanical necessity.

"3. *Thirdly*, I have undertaken to show, that the notions I advance are so far from being inconsistent with, that they are the sole foundations of morality and laws, and of rewards and punishments in society; and that the notions I explode are subversive of them."[1]

In the prosecution of his argument on this question, Collins endeavours to show, that man is a necessary agent, 1. From our experience. (By *experience* he means our own consciousness that we *are* necessary agents.) 2. From the impossibility of liberty.[2] 3. From the consideration of the Divine prescience. 4. From the nature and use of rewards and punishments; and 5. From the nature of morality.[3]

In this view of the subject, and, indeed, in the very selection of his premises, it is remarkable how completely Collins has anticipated Dr Jonathan Edwards, the most celebrated and indisputably the ablest champion of the scheme of Necessity who has since appeared. The coincidence is so perfect, that the outline given by the former, of the plan of his work, might have served with equal propriety as a preface to that of the latter.

From the above summary, and still more from the whole tenor of the *Philosophical Inquiry*, it is evident, that Collins (one of the most obnoxious writers of his day to divines of all denominations) was not less solicitous than his successor Edwards to reconcile his metaphysical notions with man's accountableness and moral agency. The remarks, accordingly, of Clarke upon Collins's work, are equally applicable to that of Edwards. It is to be regretted that they seem never to have fallen into the hands of this very acute and honest reasoner. As for Collins, it is a remarkable circumstance, that he attempted no reply to this tract of Clarke's, although he lived twelve years after its publication. The reasonings contained in it, together with those on the same subject in his correspondence with Leibnitz, and in his *Demonstration of the Being and Attributes of God*, form, in my humble opinion, the most important as well as powerful of all his metaphysical arguments.[4] The adversaries with whom he had to contend were, both of them, eminently distinguished by ingenuity and subtlety, and he seems to have put forth to the utmost his logical strength, in contending with such antagonists. "The liberty or moral agency of man (says his friend Bishop Hoadly) was a darling point to him. He excelled always, and showed a superiority to all, whenever it came into private discourse or public debate. But he never more excelled than when he was pressed with the strength Leibnitz was master of; which made him exert all his talents to set it once again in a clear light, to guard it against the evil of metaphysical obscurities, and to give the finishing stroke to a subject which must ever be the foundation of morality in man, and is the ground of the accountableness of intelligent creatures for all their actions."[1]

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[1] *A Philosophical Inquiry concerning Human Liberty*, 3d edit. Lond. 1735.

[2] See Note M M.

[3] See Note N N.

[4] Voltaire, who, in all probability, never read either Clarke or Collins, has said that the former replied to the latter only by *Theological* reasonings: "*Clarke n'a répondu à Collins qu'en Théologien.*"—(*Quest. sur l'Encyclopédie*, Art. *Liberté.*) Nothing can be more remote from the truth. The argument of Clarke is wholly *Metaphysical;* whereas, his antagonist, in various instances, has attempted to wrest to his own purposes the words of Scripture.

It is needless to say, that neither Leibnitz nor Collins admitted the fairness of the inferences which Clarke conceived to follow from the scheme of necessity: But almost every page in the subsequent history of this controversy may be regarded as an additional illustration of the soundness of Clarke's reasonings, and of the sagacity with which he anticipated the fatal errors likely to issue from the system which he opposed.

"Thus (says a very learned disciple of Leibnitz, who made his first appearance as an author about thirty years after the death of his master)[2]—thus, the same chain embraces the physical and moral worlds, binds the past to the present, the present to the future, the future to eternity."

"That wisdom which has ordained the existence of this chain, has doubtless willed that of every link of which it is composed. A Caligula is one of those links, and this link is of iron: A Marcus Aurelius is another link, and this link is of gold. *Both* are necessary parts of one whole, which could not but exist. Shall God then be angry at the sight of the iron link? What absurdity! God esteems this link at its proper value: He sees it in its cause, and he approves this cause, for it is good. God beholds moral monsters as he beholds physical monsters. Happy is the link of gold! Still more happy if he know that he is *only fortunate.*[3] He has attained the highest degree of moral perfection, and is nevertheless without pride, knowing that what he is, is the necessary result of the place which he must occupy in the chain."

"The gospel is the allegorical exposition of this system; the simile of the potter is its summary."[4] (Bonnet, T. VIII. pp. 237, 238.)

In what essential respect does this system differ from that of Spinoza? Is it not even more dangerous in its practical tendency, in consequence of the high strain of mystical devotion by which it is exalted?[5]

This objection, however, does not apply to the quotations which follow. They exhibit, without any colourings of imagination or of enthusiasm, the scheme of necessity pushed to the remotest and most alarming conclusions which it appeared to Clarke to involve; and as they express the serious and avowed creed of two of our contemporaries (both of them men of distinguished talents), may be regarded as a proof, that the zeal displayed by Clarke against the metaphysical principles which led ultimately to such results, was not so unfounded as some worthy and able inquirers have supposed.

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[1] Preface to the folio ed. of Clarke's *Works*.—The vital importance which Clarke attached to this question, has given to the concluding paragraphs of his remarks on Collins, an earnestness and a solemnity of which there are not many instances in his writings. These paragraphs cannot be too strongly recommended to the attention of those well-meaning persons, who, in our own times, have come forward as the apostles of Dr Priestley's "great and glorious Doctrine of Philosophical Necessity."

[2] Charles Bonnet, born 1720, died 1793.

[3] The words in the original are, "Heureux le chainon d'or! plus *heureux* encore, s'il sait qu'il n'est qu' *heureux*." The double meaning of *heureux*, if it render the expression less logically precise, gives it at least an epigrammatic turn, which cannot be preserved in our language.

[4] See Note O O.

[5] Among the various forms which religious enthusiasm assumes, there is a certain prostration of the mind, which, under the specious disguise of a deep humility, aims at exalting the Divine perfections, by annihilating all the powers which belong to Human Nature. "Nothing is more usual for fervent devotion (says Sir James Mackintosh, in speaking of some theories current among the Hindoos), than to dwell so long and so warmly on the meanness and worthlessness of created things, and on the all-sufficiency of the Supreme Being, that it slides insensibly from comparative to absolute language, and in the eagerness of its zeal to magnify the Deity seems to annihilate everything else."—(See *Philosophy of the Human Mind*, Vol. II. p. 529, 2d ed.)

This excellent observation may serve to account for the zeal displayed by Bonnet, and many other devout men, in favour of the Scheme of Necessity. "We have nothing (they frequently and justly remind us) but what we have received."—But the question here is simply a matter of fact, whether we have or have not *received* from *God* the gift of Free Will; and the only argument, it must be remembered, which they have yet been able to advance for the negative proposition, is, that this gift was *impossible*, even for the power of God; nay, the same argument which annihilates the power of Man, annihilates that of God also, and subjects him, as well as all his creatures, to the control of causes which he is unable to resist. So completely does this scheme defeat the pious views in which it has sometimes originated.—I say *sometimes*; for the very same argument against the liberty of the Will is employed by Spinoza, according to whom the free-agency of man involves the absurd supposition of an *imperium in imperio* in the universe.—(*Tractat. Polit.* Cap. II. § 6.)

May I be permitted to observe farther on this head, that, as one of these writers spent his life in the pay of a German prince, and as the other was the favourite philosopher of another sovereign, still more illustrious, the sentiments which they were so anxious to proclaim to the world, may be presumed to have been not very offensive, in their judgments, to the ears of their protectors?

"All that is must be (says the Baron de Grimm, addressing himself to the Duke of Saxe-Gotha)—all that is must be, even because it is; this is the only sound philosophy; as long as we do not know this universe *a priori* (as they say in the schools), ALL IS NECESSITY.[1] Liberty is a word without meaning, as you shall see in the letter of M. Diderot."

The following passage is extracted from Diderot's letter here referred to:

"I am now, my dear friend, going to quit the tone of a preacher, to take, if I can, that of a philosopher. Examine it narrowly, and you will see that the word *Liberty* is a word devoid of meaning;[2] that there are not, and that there cannot be free beings; that we are only what accords with the general order, with our organization, our education, and the chain of events. These dispose of us invincibly. We can no more conceive a being acting without a motive, than we can one of the arms of a balance acting without a weight. The motive is always exterior and foreign, fastened upon us by some cause distinct from ourselves. What deceives us, is the prodigious variety of our actions, joined to the habit which we catch at our birth, of confounding the voluntary and the free. We have been so often praised and blamed, and have so often praised and blamed others, that we contract an inveterate prejudice of believing that we and they will and act freely. But if there is no liberty, there is no action that merits either praise or blame; neither vice nor virtue, nothing that ought either to be rewarded or punished. What then is the distinction among men? The doing of good and the doing of ill! The doer of ill is one who must be destroyed, not punished. The doer of good is lucky, not virtuous. But though neither the doer of good or of ill be free, man is nevertheless a being to be modified; it is for this reason the doer of ill should be destroyed upon the scaffold. From thence the good effects of education, of pleasure, of grief, of grandeur, of poverty, &c.; from thence a philosophy full of pity, strongly attached to the good, nor more angry with the wicked, than with the whirlwind which fills one's eyes with dust. Strictly speaking, there is but one sort of causes, that is, physical causes. There is but one sort of necessity, which is the same for all beings. This is what reconciles me to humankind: it is for this reason I exhorted you to philanthropy. Adopt these principles if you think them good, or show me that they are bad. If you adopt them, they will reconcile *you* too with others and with yourself: you will neither be pleased nor angry with yourself for being what you are. Reproach others for nothing, and repent of nothing; this is the first step to wisdom. Besides this, all is prejudice and false philosophy."[3]

The prevalence of the principles here so earnestly inculcated among the higher orders in France, at a period somewhat later in the history of the monarchy, may be judged of from the occasional allusions to them in the dramatic pieces then chiefly in request at Paris. In the *Mariage de Figaro* (the popularity of which was quite unexampled), the hero of the piece, an intriguing valet in the service of a Spanish courtier, is introduced as thus moralising, in a soliloquy on his own free-agency and personal identity. Such an exhibition upon the English stage would have been universally censured as out of character and extravagant, or rather, would have been completely unintelligible to the crowds by which our theatres are filled.

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[1] The logical inference ought undoubtedly to have been, "as long as we know nothing of the universe *a priori*, we are not entitled to say of anything that it either is, or is not, necessary."

[2] Does not this remark of Diderot apply with infinitely greater force to the word *necessity*, as employed in this controversy?

[3] Nearly to the same purpose, we are told by Mr Belsham, that "the *fallacious* feeling of *remorse* is superseded by the doctrine of necessity."—(*Elem.* p. 284.) And again, "*Remorse* supposes free will. It is of little or no use in moral discipline. In a degree, it is even pernicious."—(*Ibid.* p. 406.)

Nor does the opinion of Hartley seem to have been different. "The doctrine of Necessity has a tendency to abate all resentment against men. Since all they do against us is by the appointment of God, it is rebellion against him to be offended with them."

For the originals of the quotations from Grimm and Diderot, see Note P P.

"Oh bisarre suite d'evènemens! Comment cela m'a-t-il arrivé? Pourquoi ces choses et non pas d'autres? Qui les a fixées sur ma tête? Forcé de parcourir la route où je suis entré sans le savoir, comme j'en sortirai sans le vouloir, je l'ai jonchée d'autant de fleurs que ma gaieté me la permit: encore je dis *ma* gaieté, sans savoir si elle est à moi plus que le reste, ni même qui est ce *moi* dont je m'occupe."

That this soliloquy, though put into the mouth of Figaro, was meant as a picture of the philosophical jargon at that time affected by courtiers and men of the world, will not be doubted by those who have attended to the importance of the *rolles* commonly assigned to confidential valets in French comedies, and to the habits of familiarity in which they are always represented as living with their masters. The sentiments which they are made to utter may, accordingly, be safely considered as but an echo of the lessons which they have learned from their superiors.[1]

My anxiety to state, without any interruption, my remarks on some of the most important questions to which the attention of the public was called by the speculations of Locke, of Leibnitz, of Newton, and of Clarke, has led me, in various instances, to depart from the strict order of Chronology. It is time for me, however, now to pause, and, before I proceed farther, to supply a few chasms in the foregoing sketch.

SECTION IV.

Of some Authors who have contributed, by their Critical or Historical Writings, to diffuse a Taste for Metaphysical Studies.—Bayle—Fontenelle—Addison. Metaphysical Works of Berkeley.

Among the many eminent persons who were either driven from France, or who went into voluntary exile, in consequence of the revocation of the edict of Nantz, the most illustrious by far was Bayle;[2] who, fixing his residence in Holland, and availing himself, to the utmost extent, of the religious toleration then enjoyed in that country, diffused from thence, over Europe, a greater mass of accurate and curious information, accompanied by a more splendid display of acute and lively criticism, than had ever before come from the pen of a single individual.[3] Happy! if he had been able to restrain within due bounds his passion for sceptical and licentious discussion, and to respect the feelings of the wise and good, on topics connected with religion and morality. But, in the peculiar circumstances in which he was educated, combined with the seducing profession of a literary adventurer, to which his hard fortune condemned him, such a spirit of moderation was rather to be wished than expected.

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[1] A reflection of Voltaire's on the writings of Spinoza may, I think, be here quoted without impropriety. "Vous êtes tres confus, Baruc Spinoza, mais êtes vous aussi dangereux qu'on le dit? Je soutiens que non, et ma raison c'est que vous êtes confus, que vous avez écrit en mauvais Latin, et qu'il n'y a pas dix personnes en Europe qui vous lisent d'un bout à l'autre. Quel est l'auteur dangereux? C'est celui qui est lu par les Oisifs de la Cour, et par les Dames."—(*Quest. sur l'Encyclop.* Art. *Dieu.*)

Had Voltaire kept this last remark steadily in view in his own writings, how many of those pages would he have cancelled which he has given to the world!

[2] Born in 1647, died 1705.

[3] The erudition of Bayle is greatly undervalued by his antagonist Le Clerc. "Toutes les lumières philosophiques de M. Bayle consistoient en quelque peu de Péripatétisme, qu'il avoit appris des Jésuites de Toulouse, et un peu de Cartésianisme, qu'il n'avoit jamais approfondi."—(*Bib. Choisie*, Tom. XII. p. 106.)

In the judgment of Gibbon, "Bayle's learning was chiefly confined to the Latin authors; and he had more of a certain multifarious reading than of real erudition. Le Clerc, his great antagonist, was as superior to him in that respect as inferior in every other."—(*Extraits Raisonnés de mes Lectures*, p. 62.)

When Bayle first appeared as an author, the opinions of the learned still continued to be divided between Aristotle and Descartes. A considerable number leaned, in secret, to the metaphysical creed of Spinoza and of Hobbes; while the clergy of the Roman Catholic and the Protestant churches, instead of uniting their efforts in defence of those truths which they professed in common, wasted their strength against each other in fruitless disputes and recriminations.

In the midst of these controversies, Bayle, keeping aloof as far as possible from all the parties, indulged his sceptical and ironical humour at the common expence of the various combatants. Unattached himself to any system, or, to speak more correctly, unfixed in his opinions on the most fundamental questions, he did not prosecute any particular study with sufficient perseverance to add materially to the stock of useful knowledge. The influence, however, of his writings on the taste and views of speculative men of all persuasions, has been so great, as to mark him out as one of the most conspicuous characters of his age; and I shall accordingly devote to him a larger space than may, at first sight, appear due to an author who has distinguished himself only by the extent of his historical researches, and by the sagacity and subtlety of his critical disquisitions.

We are informed by Bayle himself, that his favourite authors, during his youth, were Plutarch and Montaigne; and from *them*, it has been alleged by some of his biographers, he imbibed his first lessons of scepticism. In what manner the first of these writers should have contributed to inspire him with this temper of mind, is not very obvious. There is certainly no heathen philosopher or historian whose morality is more pure or elevated; and none who has drawn the line between superstition and religion with a nicer hand.[1] Pope has with perfect truth said of him, that " he abounds more in strokes of good nature than any other author;" to which it may be added, that he abounds also in touches of simple and exquisite *pathos*, seldom to be met with among the greatest painters of antiquity. In all these respects what a contrast does Bayle present to Plutarch!

Considering the share which Bayle ascribes to Montaigne's Essays in forming his literary taste, it is curious, that there is no separate article allotted to Montaigne in the *Historical and Critical Dictionary*. What is still more curious, there is more than one reference to this article, as if it actually existed; without any explanation of the omission (as far as I recollect) from the author or the publisher of the work. Some very interesting particulars, however, concerning Montaigne's life and writings, are scattered over the Dictionary, in the notices of other persons, with whom his name appeared to Bayle to have a sufficient connection to furnish an apology for a short episode.

It does not seem to me a very improbable conjecture, that Bayle had intended, and perhaps attempted, to write an account of Montaigne; and that he had experienced greater difficulties than he was aware of, in the execution of his design. Notwithstanding their common tendency to scepticism, no two characters were ever more strongly discriminated in their most prominent features; the doubts of the one resulting from the singular coldness of his moral temperament, combined with a subtlety and over-refinement in his habits of thinking, which rendered his ingenuity, acuteness, and erudition, more than a match for his good sense and sagacity;—the indecision of the other partaking more of the shrewd and soldier-like *étourderie* of Henry IV. when he exclaimed, after hearing two lawyers plead on opposite sides of the same question, " *Ventre St Gris! il me semble que tous les deux ont raison.*"

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[1] See, in particular, his account of the effects produced on the character of Pericles by the sublime lessons of Anaxagoras. Plutarch, it is true, had said before Bayle, that atheism is less pernicious than superstition; but how wide the difference between this paradox, as explained and qualified by the Greek philosopher, and as interpreted and applied in the *Reflections on the Comet!* Mr Addison himself seems to give his sanction to Plutarch's maxim in one of his papers on Cheerfulness. " An eminent Pagan writer has made a discourse to show, that the atheist, who denies a God, does him less dishonour than the man who owns his being, but, at the same time, believes him to be cruel, hard to please, and terrible to human nature. For my own part, says he, I would rather it should be said of me, that there was never any such man as Plutarch, than that Plutarch was ill-natured, capricious, and inhuman."—(*Spectator*, No. 494.)

Independently of Bayle's constitutional bias towards scepticism, some other motives, it is probable, conspired to induce him, in the composition of his *Dictionary*, to copy the spirit and tone of the old Academic school. On these collateral motives a strong and not very favourable light is thrown by his own candid avowal in one of his letters. " In truth (says he to his correspondent Minutoli), it ought not to be thought strange, that so many persons should have inclined to Pyrrhonism; for of all things in the world it is the most convenient. You may dispute with impunity against every body you meet, without any dread of that vexatious argument which is addressed *ad hominem*. You are never afraid of a retort; for as you announce no opinion of your own, you are always ready to abandon those of others to the attacks of sophists of every description. In a word, you may dispute and jest on all subjects without incurring any danger from the *lex talionis*."[1] It is amusing to think, that the Pyrrhonism which Bayle himself has here so ingeniously accounted for, from motives of conveniency and of literary cowardice, should have been mistaken by so many of his disciples for the sportive triumph of a superior intellect over the weaknesses and errors of human reason.[2]

The profession of Bayle, which made it an object to him to turn to account even the sweepings of his study, affords an additional explanation of the indigested mass of heterogeneous and inconsistent materials contained in his Dictionary. Had he adopted any one system exclusively, his work would have shrunk in its dimensions into a comparatively narrow compass.[3]

When these different considerations are maturely weighed, the omission by Bayle of the article *Montaigne* will not be much regretted by the admirers of the Essays. It is extremely doubtful if Bayle would have been able to seize the true spirit of Montaigne's character; and, at any rate, it is not in the delineation of character that Bayle excels. His critical acumen, indeed, in the examination of opinions and arguments, is unrivalled; but his portraits of persons commonly exhibit only the coarser lineaments which obtrude themselves on the senses of ordinary observers; and seldom, if ever, evince that discriminating and divining eye, or that sympathetic penetration into the retirements of the heart, which lend to every touch of a master artist, the never-to-be-mistaken expression of truth and nature.

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[1] " En verité, il ne faut pas trouver étrange que tant des gens aient donné dans le Pyrrhonisme. Car c'est la chose du monde le plus commode. Vous pouvez impunément disputer contre tous venans, et sans craindre ces argumens *ad hominem*, qui font quelquefois tant de peine. Vous ne craignez point la rétorsion; puisque ne soutenant rien, vous abandonnez de bon cœur à tous les sophismes et à tous les raisonnemens de la terre quelque opinion que ce soit. Vous n'êtes jamais obligé d'en venir à la défensive. En un mot, vous contestez et vous daubez sur toutes choses tout votre saoul, sans craindre la peine du talion."—*(Oeuv. Div. de Bayle*, IV. p. 537.)

[2] The estimate formed by Warburton of Bayle's character, both intellectual and moral, is candid and temperate. " A writer whose strength and clearness of reasoning can only be equalled by the gaiety, easiness, and delicacy, of his wit; who, pervading human nature with a glance, struck into the province of paradox, as an exercise for the restless vigour of his mind: who, with a soul superior to the sharpest attacks of fortune, and a heart practised to the best philosophy, had not yet enough of real greatness, to overcome that last foible of superior geniuses, the temptation of honour, which the academical exercise of wit is supposed to bring to its professors.—*(Divine Legation.)*

If there be anything objectionable in this panegyric, it is the unqualified praise bestowed on Bayle's *wit*, which, though it seldom fails in copiousness, in poignancy, or in that grave argumentative irony, by which it is still more characteristically marked, is commonly as deficient in *gaiety* and *delicacy* as that of Warburton himself.

Leibnitz seems perfectly to have entered into the peculiar temper of his adversary Bayle, when he said of him, that " the only way to make Bayle write usefully, would be to attack him when he advances propositions that are sound and true; and to abstain from attacking him, when he says anything false or pernicious."

" Le vrai moyen de faire écrire utilement M. Bayle, ce seroit de l'attaquer, lorsqu'il écrit des bonnes choses et vraies, car ce seroit le moyen de le piquer pour continuer. Au lieu qu'il ne faudroit point l'attaquer quand il en dit de mauvaises, car cela l'engagera à en dire d'autres aussi mauvaises pour soutenir les premières."—(Tom. VI. p. 273.)

Leibnitz elsewhere says of him: *Ubi bene, nemo melius.*—(Tom. I. p. 257.)

[3] " The inequality of Bayle's voluminous works (says Gibbon) is explained by his alternately writing for himself, for the bookseller, and for posterity; and if a severe critic would reduce him to a single folio, that relic, like the books of the Sybils, would become still more valuable."—(GIBBON'S *Mem.* p. 50.)

Mr Gibbon observes in another place, that, " if Bayle wrote his *Dictionary* to empty the various collections he had made, without any particular design, he could not have chosen a better plan. It permitted him everything, and obliged him to nothing. By the double freedom of a *Dictionary* and of Notes, he could pitch on what articles he pleased, and say what he pleased on those articles."—*(Extraits Raisonnés de mes Lectures*, p. 64.)

" How could such a genius as Bayle," says the same author, " employ three or four pages, and a great apparatus of learning, to examine whether Achilles was fed with marrow only; whether it was the marrow of lions and stags, or that of lions only?" &c.—*(Ibid.* p. 66.)

For a long and interesting passage with respect to Bayle's history and character, see GIBBON'S *Memoirs*, &c. Vol. I. pp. 49, 50, 51.

It furnishes some apology for the unsettled state of Bayle's opinions, that his habits of thinking were formed prior to the discoveries of the Newtonian School. Neither the vortices of Descartes, nor the monads and pre-established harmony of Leibnitz, were well calculated to inspire him with confidence in the powers of the human understanding; nor does he seem to have been led, either by taste or by genius, to the study of those exacter sciences in which Kepler, Galileo, and others, had, in the preceding age, made such splendid advances. In Geometry he never proceeded beyond a few of the elementary propositions; and it is even said (although I apprehend with little probability) that his farther progress was stopped by some defect in his intellectual powers, which disqualified him for the successful prosecution of the study.

It is not unworthy of notice, that Bayle was the son of a Calvinist minister, and was destined by his father for his own profession; that during the course of his education in a college of Jesuits he was converted to the Roman Catholic persuasion;[1] and that finally he went to Geneva, where, if he was not recalled to the Protestant faith, he was at least most thoroughly reclaimed from the errors of Popery.[2]

To these early fluctuations in his religious creed, may be ascribed his singularly accurate knowledge of controversial theology, and of the lives and tenets of the most distinguished divines of both churches;—a knowledge much more minute than a person of his talents could well be supposed to accumulate from the mere impulse of literary curiosity. In these respects he exhibits a striking resemblance to the historian of the *Decline and Fall of the Roman Empire:* Nor is the parallel between them less exact in the similar effects produced on their minds, by the polemical cast of their juvenile studies. Their common propensity to indulge in indecency is not so easily explicable. In neither does it seem to have originated in the habits of a dissolute youth; but in the wantonness of a polluted and distempered imagination. Bayle, it is well known, led the life of an anchoret;[3] and the licentiousness of his pen is, on that very account, the more reprehensible. But, everything considered, the grossness of Gibbon is certainly the more unaccountable, and perhaps the more unpardonable of the two.[4]

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[1] "For the benefit of education, the Protestants were tempted to risk their children in the Catholic Universities; and in the 22d year of his age young Bayle was seduced by the arts and arguments of the Jesuits of Thoulouse. He remained about seventeen months in their hands a voluntary captive."—(GIBBON'S *Misc. Works*, Vol. I. p. 49.)

[2] According to Gibbon, "the piety of Bayle was offended by the excessive worship of creatures; and *the study of physics* convinced him of the impossibility of transubstantiation, which is abundantly refuted by the testimony of our senses."—*(Ibid.* p. 49.)

The same author, speaking of his own conversion from Popery, observes (after allowing to his Preceptor Mr Pavillard "a handsome share" of the honour), "that it was principally effected by his private reflections;" adding the following very curious acknowledgment: "I still remember my solitary transport at the discovery of a *philosophical argument* against the doctrine of *Transubstantiation;* that the text of Scripture, which seems to inculcate the real presence, is attested only by a single sense—our sight; while the real presence itself is disproved by three of our senses—the sight, the touch, and the taste."—*(Ibid.* p. 58.) That this "*philosophical* argument" should have had any influence on the mind of Gibbon, even at the early period of life when he made "the discovery," would appear highly improbable, if the fact were not attested by himself; but as for Bayle, whose logical acumen was of a far harder and keener edge, it seems quite impossible to conceive, "that the study of physics" was at all necessary to open his eyes to the absurdity of the *real presence;* or that he would not at once have perceived the futility of appealing to our senses or to our reason, against an article of faith which professedly disclaims the authority of both.

[3] "Chaste dans ses discours, grave dans ses discours, sobre dans ses alimens, austère dans son genre de vie."—(Portrait de Bayle par M. SAURIN, dans son Sermon sur l'accord de la Religion avec la Politique.)

[4] In justice to Bayle, and also to Gibbon, it should be remembered, that over the most offensive passages in their works they have drawn the veil of the learned languages. It was reserved for the translators of the *Historical and Critical Dictionary* to tear this veil asunder, and to expose the indelicacy of their author to every curious eye. It is impossible to observe the patient industry and fidelity with which they have executed this part of their task without feelings of indignation and disgust. For such an outrage on taste and decorum, their tedious and feeble attacks on the Manicheism of Bayle offer but a poor compensation. Of all Bayle's suspected heresies, it was perhaps that which stood the least in need of a serious refutation; and, if the case had been otherwise, their incompetency to contend with such an adversary would have only injured the cause which they professed to defend.

On the mischievous tendency of Bayle's work to unsettle the principles of superficial readers, and, what is worse, to damp the moral enthusiasm of youth, by shaking their faith in the reality of virtue, it would be superfluous to enlarge. The fact is indisputable, and is admitted even by his most partial admirers. It may not be equally useless to remark the benefits which (whether foreseen or not by the author, is of little consequence) have actually resulted to literature from his indefatigable labours. *One* thing will, I apprehend, be very generally granted in his favour, that, if he has taught men to suspend their judgment, he has taught them also to think and to reason for themselves; a lesson which appeared to a late philosophical divine of so great importance, as to suggest to him a doubt, whether it would not be better for authors to state nothing but *premises*, and to leave to their readers the task of forming their own *conclusions.*[1] Nor can Bayle be candidly accused of often discovering a partiality for any particular sect of philosophers. He opposes Spinoza and Hobbes with the same spirit and ability, and apparently with the same good faith, with which he controverts the doctrines of Anaxagoras and of Plato. Even the ancient sceptics, for whose mode of philosophising he might be supposed to have felt some degree of tenderness, are treated with as little ceremony as the most extravagant of the dogmatists. He has been often accused of a leaning to the most absurd of all systems, that of the Manicheans; and it must be owned, that there is none in defence of which he has so often and so ably[2] exerted his talents; but it is easy to perceive, that, when he does so, it is not from any serious faith which he attaches to it (perhaps the contrary supposition would be nearer the truth), but from the peculiarly ample field which it opened for the display of his controversial subtlety, and of his inexhaustible stores of miscellaneous information.[3] In one passage he has pronounced with a tone of decision which he seldom assumes, that "it is absurd, indefensible, and inconsistent with the regularity and order of the universe; that the arguments in favour of it are liable to be retorted; and that, granting it to be true, it would afford no solution of the difficulties in question."[4] The apparent zeal with which, on various occasions, he has taken up its defence, may, I think, be reasonably accounted for, by the favourable opportunity it afforded him of measuring his logical powers with those of Leibnitz.[5]

To these considerations it may be added, that, in consequence of the progress of the sciences since Bayle's time, the unlimited scepticism commonly, and perhaps justly imputed to him, is much less likely to mislead than it was a century ago; while the value of his researches, and of his critical reflections, becomes every day more conspicuous, in proportion as more enlarged views of nature, and of human affairs, enable us to combine together that mass of rich but indigested materials, in the compilation of which his own opinions and principles seem to have been totally lost. Neither comprehension, indeed, nor generalisation, nor metaphysical depth,[1] are to be numbered among the characteristical attributes of his genius. Far less does he ever anticipate, by the moral lights of the soul, the slow and hesitating decisions of the understanding; or touch with a privileged hand those mysterious chords to which all the social sympathies of our frame are responsive. Had his ambition, however, been more exalted, or his philanthropy more warm and diffusive, he would probably have attempted less than he actually accomplished; nor would he have stooped to enjoy that undisputed pre-eminence which the public voice has now unanimously assigned him, among those inestimable though often ill requited authors, whom Johnson has called "the pioneers of literature."

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[1] See the preface to Bishop Butler's Sermons.

[2] Particularly in the article entitled *Paulicians.*

[3] One of the earliest as well as the ablest of those who undertook a reply to the passages in Bayle which *seem* to favour Manicheism, candidly acquits him of any serious design to recommend that system to his readers. "En répondant aux objections Manichéennes, je ne prétends faire aucun tort à M. Bayle : que je ne soupçonne nullement de les favoriser. Je suis persuadé qu'il n'a pris la liberté philosophique de dire, en bien des rencontres, le pour et le contre, sans rien dissimuler, que pour donner de l'exercice à ceux qui entendent les matières qu'il traite, et non pour favoriser ceux dont il explique les raisons."—(*Parrhasiana, ou Pensées Diverses*, p. 302, par M. Le Clerc. Amsterdam, 1699.)

[4] See the illustration upon the Sceptics at the end of the Dictionary.

[5] This supposition may be thought inconsistent with the well known fact, that the Theodicée of Leibnitz was not published till after the death of Bayle. But it must be recollected, that Bayle had previously entered the lists with Leibnitz in the article *Rorarius*, where he had urged some very acute and forcible objections against the scheme of *pre-established harmony;* a scheme which leads so naturally and obviously to that of optimism, that it was not difficult to foresee what ground Leibnitz was likely to take in defending his principles. The great aim of Bayle seems to have been to provoke Leibnitz to unfold *the whole* of his system and of its necessary consequences; well knowing what advantages in the management of such a controversy would be on the side of the assailant.

The tribute paid by Leibnitz to the memory of his illustrious antagonist deserves to be quoted. "Sperandum est, *Bælium* luminibus illis nunc circumdari, quod terris negatum est : cum credibile sit, bonam voluntatem ei nequaquam defuisse."

"Candidus insuetum miratur limen Olympi,
Sub pedibusque videt nubes et sidera Daphnis."

The suspense of judgment which Bayle's *Dictionary* inspires with respect to *facts*, is, perhaps, still more useful than that which it encourages in matters of abstract reasoning. Fontenelle certainly went much too far, when he said of history, that it was only a collection of *Fables Convenues*;—a most significant and happy phrase, to which I am sorry that I cannot do justice in an English version. But though Fontenelle pushed his maxim to an extreme, there is yet a great deal of important truth in the remark; and of this I believe every person's conviction will be stronger, in proportion as his knowledge of men and of books is profound and extensive.[2]

Of the various lessons of historical scepticism to be learned from Bayle, there is none more practically valuable (more especially in such revolutionary times as we have witnessed) than that which relates to the biographical portraits of distinguished persons, when drawn by their theological and political opponents. In illustration of this, I have only to refer to the copious and instructive extracts which he has produced from Roman Catholic writers, concerning the lives, and still more concerning the deaths, of Luther, Knox,[3] Buchanan, and various other leaders or partizans of the Reformation. It would be impossible for any well-informed Protestant to read these extracts, without indulging a smile at their incredible absurdity, if every feeling of levity were not lost in a sentiment of deep indignation at the effrontery and falsehood of their authors. In stating this observation, I have taken my examples from Roman Catholic libellers, without any illiberal prejudices against the members of that church. The injustice done by Protestants to some of the conscientious defenders of the old faith has been, in all probability, equally great; but this we have no opportunity of ascertaining here, by the same direct evidence to which we can fortunately appeal, in vindication of the three characters mentioned above. With the history of *two* of them every person in this country is fully acquainted; and I have purposely selected them in preference to others, as their *names* alone are sufficient to cover with disgrace the memory of their calumniators.[4]

A few years before the death of Bayle, Fontenelle began to attract the notice of Europe.[5] I class them together on account of the mighty influence of both on the literary taste of their contemporaries; an influence in neither case founded on any claims to original genius, or to important improvements; but on the attractions which they possessed in common, though in very different ways, as popular writers; and on the easy and agreeable access which their works opened to the opinions and speculations of the learned. Nor do I depart so far as might at first be supposed, from the order of chronology, in passing from the one to the other. For though Fontenelle survived almost to our own times (having very nearly completed a century at the time of his death), the interval between his birth and that of Bayle was only ten years, and he had actually published several volumes, both in prose and verse, before the *Dictionary* of Bayle appeared.

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[1] I speak of that metaphysical *depth* which is the exclusive result of what Newton called *patient thinking*. In logical quickness, and metaphysical subtlety, Bayle has never been surpassed.

[2] Montesquieu has expressed himself on this subject, in nearly as strong terms as Fontenelle. "Les Histoires sont des faits faux composés sur des faits vrais, ou bien à l'occasion des vrais."—(*Pensées Diverses de* MONTESQUIEU, Tom. V. de ses Œuvres. Ed. de Paris, 1818.)

[3] See Note Q Q.

[4] Of all Bayle's works, "the most useful and the least sceptical," according to Gibbon, "is his *Commentaire Philosophique* on these words of the Gospel, *Compel them to come in*."

The great object of this commentary is to establish the general principles of Toleration, and to remonstrate with the members of Protestant churches on the inconsistency of their refusing to those they esteem heretics, the same indulgence which they claim for themselves in Catholic countries. The work is diffuse and rambling, like all Bayle's compositions; but the matter is excellent, and well deserves the praise which Gibbon has bestowed on it.

[5] Bayle died in 1706. Fontenelle's first work in prose (the *Dialogues of the Dead*) was published as early as 1683, and was quickly followed by his *Conversations on the Plurality of Worlds*.

But my chief reason for connecting Fontenelle rather with the contemporaries of his youth than with those of his old age is, that, during the latter part of his life, he was left far behind in his philosophical creed (for he never renounced his faith as a Cartesian)[1] by those very pupils to whose minds he had given so powerful an impulse, and whom he had so long taught by his example, the art (till then unknown in modern times) of blending the truths of the severer sciences with the lights and graces of eloquence. Even this *eloquence*, once so much admired, had ceased, before his death, to be regarded as a model, and was fast giving way to the purer and more manly taste in writing, recommended by the precepts, and exemplified in the historical compositions of Voltaire.

Fontenelle was a nephew of the great Corneille; but his genius was, in many respects, very strongly contrasted with that of the author of the *Cid*. Of this he has himself enabled us to judge by the feeble and unsuccessful attempts in dramatic poetry, by which he was first known to the world. In these, indeed, as in all his productions, there is an abundance of ingenuity, of elegance, and of courtly refinement; but not the faintest vestige of the *mens divinior*, or of that sympathy with the higher and nobler passions which enabled Corneille to re-animate and to reproduce on the stage the heroes of ancient Rome. The circumstance, however, which more peculiarly marks and distinguishes his writings, is the *French mould* in which education and habit seem to have recast all the original features of his mind;—identifying, at the same time, so perfectly the impressions of art with the workmanship of nature, that one would think the PARISIAN, as well as the MAN, had started fresh and finished from her creative hand. Even in his *Conversations on the Plurality of Worlds*, the dry discussions with the Marchioness about the now forgotten vortices of Descartes, are enlivened throughout by a never-failing spirit of light and national gallantry, which will for ever render them an amusing picture of the manners of the times, and of the character of the author. The gallantry, it must be owned, is often strained and affected; but the affectation sits so well on Fontenelle, that he would appear less easy and graceful without it.

The only other production of Fontenelle's youth which deserves to be noticed is his *History of Oracles*; a work of which the aim was, to combat the popular belief that the oracles of antiquity were uttered by evil spirits, and that all these spirits became dumb at the moment of the Christian æra. To this work Fontenelle contributed little more than the agreeable and lively form in which he gave it to the world; the chief materials being derived from a dull and prolix dissertation on the same subject, by a learned Dutchman. The publication excited a keen opposition among divines, both Catholic and Protestant; and, in particular, gave occasion to a very angry, and, it is said, not contemptible criticism, from a member of the Society of Jesuits.[2] It is mentioned by La Harpe, as an illustration of the rapid change in men's opinions which took place during Fontenelle's life, that a book which, in his youth, was censured for its impiety, was regarded before his death as a proof of his respect for religion.

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[1] Excepting on a few metaphysical points. The chief of these were, the question concerning the origin of our ideas, and that relating to the nature of the lower animals. On the former of these subjects he has said explicitly: "L'Ancienne Philosophie n'a pas toujours eu tort. Elle a soutenu que tout ce qui étoit dans l'esprit avoit *passé par les sens*, et nous n'aurions pas mal fait de conserver cela d'elle."—*(Fragment of an intended Treatise on the Human Mind.)* On another occasion, he states his own opinion on this point, in language coinciding exactly with that of Gassendi. "A force d'opérer sur les premières idées formées par les sens, d'y ajouter, d'en retrancher, de les rendre de particulières universelles, d'universelles plus universelles encore, l'esprit les rend si différentes de ce qu'elles étoient d'abord qu'on a quelquefois peine à reconnôitre leur origine. Cependant qui voudra prendre le fil et le suivre exactement, retournera toujours de l'idée la plus sublime et la plus élevée, à quelque idée sensible et grossière."

[2] To this criticism, the only reply made by Fontenelle was a single sentence, which he addressed to a *Journalist* who had urged him to take up arms in his own defence. "Je laisserai mon censeur jouir en paix de son triomphe; je consens que le diable ait été prophète, puisque le Jesuite le veut, et qu'il croit cela plus orthodoxe."—(D'ALEMBERT, *Eloge de la Motte.)* We are told by D'Alembert, that the silence of Fontenelle, on this occasion, was owing to the advice of La

The most solid basis of Fontenelle's fame is his *History of the Academy of Sciences*, and his *Eloges of the Academicians*. Both of these works, but more especially the latter, possess, in an eminent degree, all the charms of his former publications, and are written in a much simpler and better taste than any of the others. The materials, besides, are of inestimable value, as succinct and authentic records of one of the most memorable periods in the history of the human mind; and are distinguished by a rare impartiality towards the illustrious dead, of all countries, and of all persuasions. The philosophical reflections, too, which the author has most skilfully interwoven with his literary details, discover a depth and justness of understanding far beyond the promise of his juvenile Essays; and afford many proofs of the soundness of his logical views,[1] as well as of his acute and fine discrimination of the varieties and shades of character, both intellectual and moral.

The chief and distinguishing merit of Fontenelle, as the historian of the Academy, is the happy facility with which he adapts the most abstruse and refined speculations to the comprehension of ordinary readers. Nor is this excellence purchased by any sacrifice of scientific precision. What he aims at is nothing more than an outline; but this outline is always executed with the firm and exact hand of a master. "When employed in composition (he has somewhere said) my first concern is to be certain that I myself understand what I am about to write;" and on the utility of this practice every page of his Historical Memoirs may serve as a comment.[2]

As a writer of *Eloges*, he has not been equalled (if I may be allowed to hazard my own opinion) by any of his countrymen. Some of those, indeed, by D'Alembert and by Condorcet, manifest powers of a far higher order than belonged to Fontenelle; but neither of these writers possessed Fontenelle's incommunicable art of interesting the curiosity and the feelings of his readers in the fortunes of every individual whom he honoured by his notice. In this art it is not improbable that they might have succeeded better had they imitated Fontenelle's self-denial in sacrificing the fleeting praise of brilliant colouring, to the fidelity and lasting effect of their portraits; a self-denial which in *him* was the more meritorious, as his great ambition plainly was to unite the reputation of a *bel-esprit* with that of a philosopher. A justly celebrated academician of the present times (M. Cuvier), who has evidently adopted Fontenelle as his model, has accordingly given an interest and truth to his *Eloges*, which the public had long ceased to expect in that species of composition.[3]

But the principal charm of Fontenelle's *Eloges*

Motte. "Fontenelle bien tenté de terrasser son adversaire par la facilité qu'il y trouvoit, fut retenu par les avis prudens de La Motte; cet ami lui fit craindre de s'aliéner par sa réponse une société qui s'appeloit *Légion*, quand on avoit affaire au dernier de ses membres." The advice merits the attention of philosophers in all countries, for the spirit of Jesuitism is not confined to the Church of Rome.

[1] An instance of this which happens at present to recur to my memory, may serve to illustrate and to confirm the above remark. It is unnecessary to point out its coincidence with the views which gave birth to the new nomenclature in chemistry.

"If languages had been the work of philosophers, they might certainly be more easily learned. Philosophers would have established everywhere a systematical uniformity, which would have proved a safe and infallible guide; and the manner of forming a derivative word, would, as a necessary consequence, have suggested its signification. The uncivilised nations, who are the first authors of languages, fell naturally into that notion with respect to certain *terminations*, all of which have some common property or virtue; but that advantage, unknown to those who had it in their hands, was not carried to a sufficient extent."

[2] From this praise, however, must be excepted, the mysterious jargon in which (after the example of some of his contemporaries) he has indulged himself in speaking of the geometry and calculus of infinites. "Nous le disons avec peine (says D'Alembert), et sans vouloir outrager les manes d'un homme célèbre qui n'est plus, il n'y a peut-être point d'ouvrage où l'on trouve des preuves plus fréquentes de l'abus de la métaphysique, que dans l'ouvrage très connu de M. Fontenelle, qui a pour titre *Elémens de la Géométrie de l'Infini*; ouvrage dont la lecture est d'autant plus dangereuse aux jeunes géomètres que l'auteur y présente les sophismes avec une sorte d'élégance et de grace, dont le sujet ne paroissoit pas susceptible."—(*Mélanges*, &c. Tom. V. p. 264.)

[3] D'Alembert, in his ingenious parallel of Fontenelle and La Motte, has made a remark on Fontenelle's style when he aims at simplicity, of the justness of which *French* critics alone are competent judges. "L'un et l'autre ont écrit en prose avec beaucoup de clarté, d'élégance, de simplicité même; mais La Motte avec une simplicité plus naturelle, et Fontenelle

arises from the pleasing pictures which they everywhere present of genius and learning in the scenes of domestic life. In this respect, it has been justly said of them by M. Suard,[1] that "they form the noblest monument ever raised to the glory of the sciences and of letters." Fontenelle himself, in his *Eloge of Varignon*, after remarking, that in *him* the simplicity of his character was only equalled by the superiority of his talents, finely adds, "I have already bestowed so often the same praise on other members of this academy, that it may be doubted whether it is not less due to the individuals, than to the sciences which they cultivated in common." What a proud reply does this reflection afford to the Machiavellian calumniators of philosophy!

The influence of these two works of Fontenelle on the studies of the rising generation all over Europe, can be conceived by those alone who have compared them with similar productions of an earlier date. Sciences which had long been immured in colleges and cloisters, began at length to breathe the ventilated and wholesome air of social life. The union of philosophy and the fine arts, so much boasted of in the schools of ancient Greece, seemed to promise a speedy and invigorated revival. Geometry, Mechanics, Physics, Metaphysics, and Morals, became objects of pursuit in courts and in camps; the accomplishments of a scholar grew more and more into repute among the other characteristics of a gentleman: and (what was of still greater importance to the world) the learned discovered the secret of cultivating the graces of writing, as a necessary passport to truth, in a refined but dissipated age.

Nor was this change of manners confined to one of the sexes. The other sex, to whom nature has entrusted the first development of our intellectual and moral powers, and who may, therefore, be regarded as the chief *medium* through which the progress of the mind is continued from generation to generation, shared also largely in the general improvement. Fontenelle aspired above all things to be the philosopher of the Parisian circles; and certainly contributed not a little to diffuse a taste for useful knowledge among women of all conditions in France, by bringing it into vogue among the higher classes. A reformation so great and so sudden could not possibly take place, without giving birth to much affectation, extravagance, and folly; but the whole analogy of human affairs encourages us to hope, that the inconveniencies and evils connected with it will be partial and temporary, and its beneficial results permanent and progressive.[2]

Among the various moral defects imputed to Fontenelle, that of a complete apathy and in-

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avec une simplicité plus étudiée: car la simplicité peut l'être, et dès lors elle devient manière, et cesse d'être modèle." An idea very similar to this is happily expressed by Congreve, in his portrait of *Amoret:*

Coquet and Coy at once her air,
 Both studied, though both seem neglected:
Careless she is with artful care,
 Affecting to seem unaffected.

[1] *Notice sur la Vie et les Ecrits du Docteur Robertson.* (Paris, 1817.)

[2] Among the various other respects in which Fontenelle contributed to the intellectual improvement of his countrymen, it ought to be mentioned, that he was one of the first writers in France who diverted the attention of metaphysicians from the old topics of scholastic discussion, to a philosophical investigation of the principles of the fine arts. Various original hints upon these subjects are scattered over his works: but the most favourable specimens of his talents for this very delicate species of analysis are to be found in his *Dissertation on Pastorals*, and in his *Theory concerning the Delight we derive from Tragedy.** His speculations, indeed, are not always just and satisfactory; but they are seldom deficient in novelty or refinement. Their principal fault, perhaps, arises from the author's disposition to carry his refinements too far; in consequence of which, his theories become chargeable with that sort of sublimated ingenuity which the French epithet *Alambiqué* expresses more precisely and forcibly than any word in our language.

Something of the same philosophical spirit may be traced in Fenelon's *Dialogues on Eloquence*, and in his *Letter on Rhetoric and Poetry.* The former of these treatises, besides its merits as a speculative discussion, contains various practical hints, well entitled to the attention of those who aspire to eminence as public speakers; and of which the most apparently trifling claim some regard, as the results of the author's reflections upon an art which few ever practised with greater success.

Let me add, that both of these eminent men (who may be regarded as the fathers of philosophical criticism in France) were zealous partizans and admirers of the Cartesian metaphysics. It is this *critical* branch of metaphysical science which, sensibility to all concerns but his own is by far the most prominent. A letter of the Baron de Grimm, written immediately after Fontenelle's death, but not published till lately, has given a new circulation in this country to some anecdotes injurious to his memory, which had long ago fallen into oblivion or contempt in France. The authority, however, of this adventurer, who earned his subsistence by collecting and retailing, for the amusement of a German Prince, the literary scandal of Paris, is not much to be relied on in estimating a character with which he does not appear to have had any opportunity of becoming personally acquainted; more especially as, during Fontenelle's long decline, the great majority of men of letters in France were disposed to throw his merits into the shade, as an acceptable homage to the rising and more dazzling glories of Voltaire.[1] It is in the Academical Memoirs of D'Alembert and Condorcet (neither of whom can be suspected of any unjust prejudice against Voltaire, but who were both too candid to sacrifice truth to party feelings) that we ought to search for Fontenelle's real portrait:[2] Or rather (if it be true, as Dr Hutcheson has somewhere remarked, that "men have commonly the good or bad qualities which they ascribe to mankind") the most faithful *Eloge* on Fontenelle himself is to be found in those which he has pronounced upon others.

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* In the judgment of Mr Hume, "there is not a finer piece of criticism than Fontenelle's *Dissertation on Pastorals;* in which, by a number of reflections and philosophical reasonings, he endeavours to fix the just medium between simplicity and refinement, which is suitable to that species of poetry."

That the character of Fontenelle would have been more amiable and interesting, had his virtues been less the result of cold and prudent calculation, it is impossible to dispute. But his conduct through life was pure and blameless; and the happy serenity of his temper, which prolonged his life till he had almost completed his hundredth year, served as the best comment on the spirit of that mild and benevolent philosophy, of which he had laboured so long to extend the empire.

It is a circumstance almost singular in his history, that since the period of his death, his reputation, both as a man and as an author, has been gradually rising. The fact has been as remarkably the reverse with most of those who have calumniated his memory.

While the circle of mental cultivation was thus rapidly widening in France, a similar progress was taking place, upon a larger scale, and under still more favourable circumstances, in England. To this progress nothing contributed

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in my opinion, has been most successfully cultivated by French writers; although too many of them have been infected (after the example of Fontenelle) with the disease of sickly and of *hyper-metaphysical* subtlety.

From this censure, however, must be excepted the Abbé Dubos, whose *Critical Reflections on Poetry and Painting* is one of the most agreeable and instructive works that can be put into the hands of youth. Few books are better calculated for leading their minds gradually from literature to philosophy. The author's theories, if not always profound or just, are in general marked with good sense as well as with ingenuity; and the subjects to which they relate are so peculiarly attractive, as to fix the attention even of those readers who have but little relish for speculative discussions. "Ce qui fait la bonté de cet ouvrage (says Voltaire) c'est qu'il n'y a que peu d'erreurs, et beaucoup de réflexions vraies, nouvelles, et profondes. Il manque cependant d'ordre et sur-tout de précision; il auroit pu être écrit avec plus de feu, de grace, et d'elégance; *mais l'écrivain pense et fait penser*."—(*Siècle de Louis XIV.*)

[1] As to Voltaire himself, it must be mentioned, to his honour, that though there seems never to have been much cordiality between him and Fontenelle, he had yet the magnanimity to give a place to this Nestor of French literature in his catalogue of the eminent persons who adorned the reign of Louis XIV.: a tribute of respect the more flattering, as it is the single instance in which he has departed from his general rule of excluding from his list the names of all his living contemporaries. Even Fontenelle's most devoted admirers ought to be satisfied with the liberality of Voltaire's eulogy, in which, after pronouncing Fontenelle "the most universal genius which the age of Louis XIV. had produced," he thus sums up his merits as an author. "Enfin on l'a regardé comme le premier des hommes dans l'art nouveau de répandre de la lumière et des graces sur les sciences abstraites, et il a eu du mérite dans tous les autres genres qu'il a traités. Tant de talens ont été soutenus par la connoissance des langues et de l'histoire, et *il a été sans contredit au-dessus de tous les sçavans qui n'ont pas eu le don de l'invention.*"

[2] Condorcet has said expressly, that his apathy was confined entirely to what regarded himself; and that he was always an active, though frequently a concealed friend, where his good offices could be useful to those who deserved them. "On a cru Fontenelle insensible, parce que sachant mâitriser les mouvemens de son âme il se conduisoit d'après son esprit, toujours juste et toujours sage. D'ailleurs, il avoit consenti sans peine à conserver cette réputation d'insensibilité; il avoit souffert les plaisanteries de ses societés sur sa froideur, sans chercher à les détromper, parce que, bien sûr que les vraies amis n'en seroit pas la dupe, il voyoit dans cette réputation un moyen commode de se délivrer des indifférens sans blésser leur amour-propre."—(*Eloge de Fontenelle, par* CONDORCET.)

Many of Fontenelle's sayings, the import of which must have depended entirely on circumstances of time and place unknown to us, have been absurdly quoted to his disadvantage, in their literal and most obvious acceptation. "I hate war (said he), for it spoils conversation." Can any just inference be drawn from the levity of this convivial sally, against the humanity of the person who uttered it? Or rather, when connected with the characteristical *finesse* of Fontenelle's wit, does it not lead to a conclusion precisely opposite?

more powerfully than the periodical papers published under various titles by Addison[1] and his associates. The effect of these in reclaiming the public taste from the licentiousness and grossness introduced into England at the period of the Restoration; in recommending the most serious and important truths by the united attractions of wit, humour, imagination, and eloquence; and, above all, in counteracting those superstitious terrors which the weak and ignorant are so apt to mistake for religious and moral impressions—has been remarked by numberless critics, and is acknowledged even by those who felt no undue partiality in favour of the authors.[2] Some of the papers of Addison, however, are of an order still higher, and bear marks of a mind which, if early and steadily turned to philosophical pursuits, might have accomplished much more than it ventured to undertake. His frequent references to the *Essay on Human Understanding*, and the high encomiums with which they are always accompanied, show how successfully he had entered into the spirit of that work, and how completely he was aware of the importance of its object. The popular nature of his publications, indeed, which rendered it necessary for him to avoid everything that might savour of scholastic or of metaphysical discussion, has left us no means of estimating his philosophical depth, but what are afforded by the *results* of his thoughts on the particular topics which he has occasion to allude to, and by some of his incidental comments on the scientific merits of preceding authors. But these means are sufficiently ample to justify a very high opinion of his sound and unprejudiced judgment, as well as of the extent and correctness of his literary information. Of his powers as a logical reasoner he has not enabled us to form an estimate; but none of his contemporaries seem to have been more completely tinctured with all that is most valuable in the metaphysical and ethical systems of his time.[3]

But what chiefly entitles the name of Addison to a place in this Discourse, is his *Essays on the Pleasures of Imagination;* the first attempt in England to investigate the principles of the fine arts; and an attempt which, notwithstanding many defects in the execution, is entitled to the praise of having struck out a new avenue to the study of the human mind, more alluring than any which had been opened before. In this respect, it forms a most important supplement to Locke's *Survey of the Intellectual Powers ;* and it has, accordingly, served as a text, on which the greater part of Locke's disciples have been eager to offer their comments and their corrections. The progress made by some of these in exploring this interesting region has been great; but let not Addison be defrauded of his claims as a discoverer.

Similar remarks may be extended to the hints suggested by Addison on Wit, on Humour, and on the causes of Laughter. It cannot, indeed, be said of him, that he exhausted any one of these subjects; but he had at least the merit of starting them as problems for the consideration of philosophers; nor would it be easy to name among his successors, a single writer who has made so important a step towards their solution, as the original proposer.

The philosophy of the papers to which the foregoing observations refer, has been pronounced to be slight and superficial, by a crowd of modern metaphysicians, who were but ill entitled to erect themselves into judges on such a question.[4] The singular simplicity and perspicuity of Addison's style have contributed much to the prevalence of this prejudice. Eager for the instruction, and unambitious of the admiration of the multitude, he everywhere studies to bring himself down to their level; and even when he thinks with the greatest originality, and writes with the most inimitable felicity, so easily do we enter into the train of his ideas, that we can hardly persuade ourselves that we could not have thought and written in the same manner. He has somewhere said of "fine writing," that it "consists of sentiments which are natural, without being obvious:" and his definition has been applauded by Hume, as at once concise and just. Of the thing defined, his own periodical essays exhibit the most perfect examples.

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[1] Born in 1672, died in 1719.

[2] See Pope's *Imitations of Horace*, Book II. Epistle I. "Unhappy Dryden," &c. &c.

[3] I quote the following passage from Addison, *not* as a specimen of his metaphysical acumen, but as a proof of his good sense in divining and obviating a difficulty which I believe most persons will acknowledge occurred to themselves when they first entered on metaphysical studies :—

"Although we divide the soul into several powers and faculties, there is no such division in the soul itself, since it is *the whole soul* that remembers, understands, wills, or imagines. Our manner of considering the memory, understanding, will, imagination, and the like faculties, is for the better enabling us to express ourselves in such abstracted subjects of speculation, not that there is any such division in the soul itself." In another part of the same paper, Addison observes, that "what we call the faculties of the soul are only the different ways or modes in which the soul can exert herself."—(*Spectator*, No. 600.)

For some important remarks on the words *Powers* and *Faculties*, as applied to the Mind, see Locke, B. II. Ch. xxi. § 20.

[4] See Note R R.

To this simplicity and perspicuity, the wide circulation which his works have so long maintained among all classes of readers, is in a great measure to be ascribed. His periods are not constructed, like those of Johnson, to "elevate and surprise," by filling the ear and dazzling the fancy; but we close his volumes with greater reluctance, and return to the perusal of them with far greater alacrity. Franklin, whose fugitive publications on political topics have had so extraordinary an influence on public opinion, both in the Old and New Worlds, tells us that his style in writing was formed upon the model of Addison: Nor do I know anything in the history of his life which does more honour to his shrewdness and sagacity. The copyist, indeed, did not possess the gifted hand of his master,—*Museo contingens cuncta lepore;* but such is the effect of his plain and seemingly artless manner, that the most profound conclusions of political economy assume, in his hands, the appearance of indisputable truths; and some of them, which had been formerly confined to the speculative few, are already current in every country of Europe, as proverbial maxims.[1]

To touch, however slightly, on Addison's other merits, as a critic, as a wit, as a speculative politician, and, above all, as a moralist, would lead me completely astray from my present object. It will not be equally foreign to it to quote the two following short passages, which, though not strictly *metaphysical*, are, both of them, the result of metaphysical habits of thinking, and bear a stronger resemblance than anything I recollect among the wits of Queen Anne's reign, to the best philosophy of the present age. They approach, indeed, very nearly to the philosophy of Turgot and of Smith.

"Among other excellent arguments for the immortality of the soul, there is one drawn from the perpetual progress of the soul to its perfection, without a possibility of ever arriving at it; which is a hint that I do not remember to have seen opened and improved by others who have written on this subject, though it seems to me to carry a great weight with it. A brute arrives at a point of perfection that he can never pass. In a few years he has all the endowments he is capable of; and were he to live ten thousand more, would be the same thing he is at present. Were a human soul thus at a stand in her accomplishments, were her faculties to be full-blown, and incapable of further enlargement, I would imagine it might fall away insensibly, and drop at once into a state of annihilation. But can we believe a thinking being, that is in a perpetual progress of improvement, and travelling on from perfection to perfection, after having just looked abroad into the works of its Creator, and made a few discoveries of his infinite goodness, wisdom, and power, must perish at her first setting out, and in the very beginning of her inquiries?"[2]

The philosophy of the other passage is not unworthy of the author of the *Wealth of Nations.* The *thought* may be traced to earlier writers, but certainly it was never before presented with the same fulness and liveliness of illustration; nor do I know, in all Addison's works, a finer instance of his solicitude for the improvement of his fair readers, than the address with which he here insinuates one of the sublimest moral lessons, while apparently aiming only to amuse them with the geographical history of the muff and the tippet.

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[1] The expressions "*Laissez nous faire,*" and "*pas trop gouverner,*" which comprise, in a few words, two of the most important lessons of Political Wisdom, are indebted chiefly for their extensive circulation to the short and luminous comments of Franklin.—(See his *Political Fragments*, § 4.)

[2] This argument has been prosecuted with great ingenuity and force of reasoning (blended, however, with some of the peculiarities of his Berkeleian metaphysics) by the late Dr James Hutton.—(See his *Investigation of the Principles of Knowledge*, Vol. III. p. 195, *et seq.* Edin. 1794.)

"Nature seems to have taken a particular care to disseminate her blessings among the different regions of the world, with an eye to the mutual intercourse and traffic among mankind; that the natives of the several parts of the globe might have a kind of dependance upon one another, and be united together by their common interest. Almost every *degree* produces something peculiar to it. The food often grows in one country, and the sauce in another. The fruits of Portugal are corrected by the products of Barbadoes; the infusion of a China plant, sweetened with the pith of an Indian cane. The Philippine Islands give a flavour to our European bowls. The single dress of a woman of quality is often the product of a hundred climates. The muff and the fan come together from the opposite ends of the earth. The scarf is sent from the torrid zone, and the tippet from beneath the pole. The brocade petticoat rises out of the mines of Peru, and the diamond necklace out of the bowels of Indostan."

But I must not dwell longer on the fascinating pages of Addison. Allow me only, before I close them, to contrast the last extract with a remark of Voltaire, which, shallow and contemptible as it is, occurs more than once, both in verse and in prose, in his voluminous writings.

> Il murit, à Moka, dans le sable Arabique,
> Ce Caffé nécessaire aux pays des frimats;
> Il met la Fièvre en nos climats,
> Et le remède en Amerique.
>
> (*Epitre au Roi du Prusse*, 1759.)

And yet Voltaire is admired as a philosopher by many who will smile to hear this title bestowed upon Addison!

It is observed by Akenside, in one of the notes to the *Pleasures of Imagination*, that "Philosophy and the Fine Arts can hardly be conceived at a greater distance from each other than at the Revolution, when Locke stood at the head of one party, and Dryden of the other." He observes, also, that "a very great progress towards their re-union had been made within these few years." To this progress the chief impulse was undoubtedly given by Addison and Shaftesbury.

Notwithstanding, however, my strong partiality for the former of these writers, I should be truly sorry to think, with Mr Hume, that "Addison will be read with pleasure when Locke shall be *entirely forgotten*."—(*Essay on the Different Species of Philosophy.*)

A few years before the commencement of these periodical works, a memorable accession was made to metaphysical science, by the publication of Berkeley's *New Theory of Vision*, and of his *Principles of Human Knowledge*. Possessed of a mind which, however inferior to that of Locke in depth of reflection and in soundness of judgment, was fully its equal in logical acuteness and invention, and in learning, fancy, and taste, far its superior,—Berkeley was singularly fitted to promote that re-union of Philosophy and of the Fine Arts which is so essential to the prosperity of both. Locke, we are told, despised poetry; and we know from one of his own letters, that, among our English poets, his favourite author was Sir Richard Blackmore. Berkeley, on the other hand, courted the society of all, from whose conversation and manners he could hope to add to the embellishments of his genius; and although himself a decided and High Church Tory,[1] lived in habits of friendship with Steele and Addison, as well as with Pope and Swift. Pope's admiration of him seems to have risen to a sort of enthusiasm. He yielded to Berkeley's decision on a very delicate question relating to the exordium of the *Essay on Man*; and on his moral qualities he has bestowed the highest and most unqualified eulogy to be found in his writings.

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[1] See a volume of Sermons, preached in the chapel of Trinity College, Dublin. See also a Discourse addressed to Magistrates, &c. printed in 1736. In both of these publications, the author carries his Tory principles so far, as to represent the doctrine of passive obedience and non-resistance as an essential article of the Christian faith. "The Christian religion makes every legal constitution sacred, by commanding our submission thereto. *Let every soul be subject to the higher powers*, saith St Paul, *for the powers that be are ordained of God.*"

> "Even in a Bishop I can spy desert;
> Secker is decent; Rundle has a heart;
> Manners with candour are to Benson given;
> To Berkeley every virtue under Heaven."

With these intellectual and moral endowments, admired and blazoned as they were by the most distinguished wits of his age, it is not surprising that Berkeley should have given a popularity and fashion to metaphysical pursuits, which they had never before acquired in England. Nor was this popularity diminished by the boldness of some of his paradoxes: on the contrary, it was in no small degree the *effect* of them; the great bulk of mankind being always prone to mistake a singularity or eccentricity of thinking, for the originality of a creative genius.

The solid additions, however, made by Berkeley to the stock of human knowledge were important and brilliant. Among these, the first place is unquestionably due to his *New Theory of Vision;* a work abounding with ideas so different from those commonly received, and, at the same time, so profound and refined, that it was regarded by all but a few accustomed to deep metaphysical reflection, rather in the light of a philosophical romance, than of a sober inquiry after truth. Such, however, has been since the progress and diffusion of this sort of knowledge, that the leading and most abstracted doctrines contained in it, form now an essential part of every elementary treatise of optics, and are adopted by the most superficial smatterers in science as fundamental articles of their faith.

Of a theory, the outlines of which cannot fail to be familiar to a great majority of my readers, it would be wholly superfluous to attempt any explanation here, even if it were consistent with the limits within which I am circumscribed. Suffice it to observe, that its chief aim is to distinguish the immediate and natural objects of sight from the *seemingly instantaneous* conclusions which experience and habit teach us to draw from them in our earliest infancy; or, in the more concise metaphysical language of a later period, to draw the line between the *original* and the *acquired perceptions* of the eye. They who wish to study it in detail, will find ample satisfaction, and, if they have any relish for such studies, an inexhaustible fund of entertainment, in Berkeley's own short but masterly exposition of his principles, and in the excellent comments upon it by Smith of Cambridge; by Porterfield; by Reid; and, still more lately, by the author of the *Wealth of Nations.*[1]

That this doctrine, with respect to the *acquired perceptions* of sight, was quite unknown to the best metaphysicians of antiquity, we have direct evidence in a passage of Aristotle's *Nicomachian Ethics,* where he states the distinction between those endowments which are the immediate gift of nature, and those which are the fruit of custom and habit. In the former class, he ranks the perceptions of sense, mentioning particularly the senses of seeing and of hearing. The passage (which I have transcribed in a *Note*) is curious, and seems to me decisive on the subject.[2]

The misapprehensions of the ancients on this very obscure question will not appear surprising, when it is considered, that *forty* years after the publication of Berkeley's *Theory of Vision,* and *sixty* years after the date of Locke's *Essay,* the subject was so imperfectly understood in France, that Condillac (who is, to this day, very generally regarded by his countrymen as the father of genuine logic and metaphysics) combated at great length the conclusions of the English philosophers concerning the *acquired* perceptions of sight; affirming that "the eye judges *naturally* of figures, of magnitudes, of situations, and of distances." His argument in support of this opinion is to be found in the sixth section of his *Essay on the Origin of Human Knowledge.*

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[1] By this excellent judge, Berkeley's *New Theory of Vision* is pronounced to be "one of the finest examples of Philosophical Analysis that is to be found in our own, or any other language."—(*Essays on Philosophical Subjects.* Lond. 1795, p. 215.)

[2] Οὐ γὰρ ἐκ τοῦ πολλάκις ἰδεῖν, ἢ πολλάκις ἀκοῦσαι τας ἀισθησεῖς ἔλαβομεν, ἀλλ' ἀναπάλιν, ἔχοντες ἐχρησάμεθα, οὐ χρησάμενοι ἔχομεν. (*Ethic. Nicomach.* Lib. ii. cap. 1.)

"For it is not from seeing often, or from hearing often, that we get these senses; but, on the contrary, instead of getting them by using them, we use them because we have got them."

Had Aristotle been at all aware of the distinction so finely illustrated by Berkeley, instead of appealing to the perceptions of these two senses, as instances of endowments coeval with our birth, he would have quoted them as the most striking of all examples of the effects of custom in apparently identifying our acquired powers with our original faculties.

It is difficult to suppose, that a person of mature years, who had read and studied Locke and Berkeley with as much care and attention as Condillac appears to have bestowed on them, should have reverted to this ancient and vulgar prejudice; without suspecting that his metaphysical depth has been somewhat overrated by the world.[1] It is but justice, however, to Condillac to add, that, in a subsequent work, he had the candour to acknowledge and to retract his error;—a rare example of that disinterested love of truth, which is so becoming in a philosopher. I quote the passage (in a literal, though somewhat abridged version), not only to show, that, in the above statement, I have not misrepresented his opinion, but because I consider this remarkable circumstance in his literary history as a peculiarly amiable and honourable *trait* in his character.

"We cannot recall to our memory the ignorance in which we were born: It is a state which leaves no trace behind it. We only recollect our ignorance of those things, the knowledge of which we recollect to have acquired; and to remark what we acquire, some previous knowledge is necessary. That memory which now renders us so sensible of the step from one acquisition to another, cannot remount to the first steps of the progress; on the contrary, it supposes them already made; and hence the origin of our disposition to believe them connate with ourselves. To say that we have learnt to see, to hear, to taste, to smell, to touch, appears a most extraordinary paradox. It seems to us that nature gave us the complete use of our senses the moment she formed them, and that we have always made use of them without study, because we are no longer obliged to study in order to use them. I retained these prejudices at the time I published my Essay on the *Origin of Human Knowledge;* the reasonings of Locke on a man born blind, to whom the sense of sight was afterwards given, did not undeceive me: and *I maintained against this philosopher that the eye judges naturally of figures, of sizes, of situations, and of distances.*"—Nothing short of his own explicit avowal could have convinced me, that a writer of so high pretensions and of such unquestionable ingenuity as Condillac, had really commenced his metaphysical career under so gross and unaccountable a delusion.

In bestowing the praise of originality on Berkeley's *Theory of Vision,* I do not mean to say, that the *whole* merit of this Theory is exclusively his own. In this, as in most other cases, it may be presumed, that the progress of the human mind has been gradual: And, in point of fact, it will, on examination, be found, that Berkeley only took up the inquiry where Locke dropped it; following out his principles to their remoter consequences, and placing them in so great a variety of strong and happy lights, as to bring a doctrine till *then* understood but by a few, within the reach of every intelligent and attentive reader. For my own part, on comparing these two philosophers together, I am at a loss whether most to admire the powerful and penetrating sagacity of the one, or the fertility of invention displayed in the illustrations of the other. What can be more clear and forcible than the statement of Locke quoted in the Note below; and what an idea does it convey of his superiority to Condillac, when it is considered, that he anticipated *à priori* the same doctrine which was afterwards confirmed by the fine analysis of Berkeley, and demonstrated by the judicious experiments of Cheselden; while the

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[1] Voltaire, at an earlier period, had seized completely the scope of Berkeley's theory; and had explained it with equal brevity and precision, in the following passage of his *Elements of the Newtonian Philosophy:*—

"Il faut absolument conclure, que les distances, les grandeurs, les situations ne sont pas, à proprement parler, des choses visibles, c'est a dire, ne sont pas les objets propres et immédiats de la vue. L'objet propre et immédiat de la vue n'est autre chose que la lumière colorée: tout le reste, nous ne le sentons qu'a la longue et par expérience. Nous apprenons à voir, précisément comme nous apprenons à parler et à lire. La différence est, que l'art de voir est plus facile, et que la nature est également à tous notre maitre.

"Les jugemens soudains, presque uniformes, que toutes nos âmes à un certain age portent des distances, des grandeurs, des situations, nous font penser, qu'il n'y a qu'à ouvrir les yeux pour voir la manière dont nous voyons. On se trompe, il y faut le secours des autres sens. Si les hommes n'avoient que le sens de la vue, ils n'auroient aucun moyen pour connôitre l'étendue en longeur, largeur et profondeur, et un pur esprit ne la connôitroit peut-être, à moins que Dieu ne la lui révélât."—*Phys. Newton*, Chap. 7.

French metaphysician, with all this accumulation of evidence before him, relapsed into a prejudice transmitted to modern times, from the very infancy of optical science![1]

I believe it would be difficult to produce from any writer prior to Locke, an equal number of important facts relating to the intellectual phenomena, as well observed, and as unexceptionably described, as those which I have here brought under my reader's eye. It must appear evident, besides, to all who have studied the subject, that Locke has, in this passage, enunciated, in terms the most precise and decided, the same general conclusion concerning the effect of constant and early *habits*, which it was the great object of Berkeley's *Theory of Vision* to establish, and which, indeed, gives to that work its chief value, when considered in connection with the Philosophy of the Human Mind.

Berkeley himself, it is to be observed, by no means lays claim to that complete novelty in his *Theory of Vision*, which has been ascribed to it by many who, in all probability, derived their whole information concerning it from the traditional and inexact transcripts of book-making historians. In the introductory sentences of his Essay, he states very clearly and candidly the conclusions of his immediate predecessors on this class of our perceptions; and explains, with the greatest precision, in what particulars his own opinion differs from theirs. "It is, I think, *agreed by all*, that distance, of itself, cannot be seen. For distance being a line directed end-wise to the eye, it projects only one point in the fund of the eye, which point remains invariably the same, whether the distance be longer or shorter

"I find it also acknowledged, that the estimate we make of the distance of objects *considerably remote*, is rather an act of judgment grounded on *experience*, than of sense. For example, when I perceive a great number of intermediate objects, such as houses, fields, rivers, and the like, which I have experienced to take

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[1] "We are farther to consider," says Locke, "concerning perception, that the ideas we receive by sensation are often in grown people altered by the judgment, without our taking notice of it. When we set before our eyes a round globe, of any uniform colour, *v. g.* gold, alabaster, or jet, it is certain that the idea thereby imprinted in our mind is of a flat circle, variously shadowed, with several degrees of light and brightness coming to our eyes. But we having by use been accustomed to perceive what kind of appearance convex bodies are wont to make in us, what alterations are made in the reflections of light by the difference of the sensible figure of bodies; the judgment presently, by an habitual custom, alters the appearances into their causes, so that, from what truly is variety of shadow or colour, collecting the figure it makes it pass for a mark of figure, and frames to itself the perception of a convex figure, and an uniform colour; when the idea we receive from thence is only a plane variously coloured, as is evident in painting. * * * *

"But this is not, I think, usual in any of our ideas, but those received by sight;[*] because sight, the most comprehensive of all our senses, conveying to our minds the ideas of lights and colours, which are peculiar only to that sense; and also the far different ideas of space, figure, or motion, the several varieties whereof change the appearances of its proper objects, viz. light and colours, we bring ourselves by use to judge of the one by the other. This, in many cases, by a settled habit in things whereof we have frequent experience, is performed so constantly and so quick, that we take *that* for the perception of our sensation, which is an idea formed by our judgment; so that one, viz. that of sensation, serves only to excite the other, and is scarce taken notice of itself: as a man who reads or hears with attention or understanding, takes little notice of the characters or sounds, but of the ideas that are excited in him by them.

"Nor need we wonder that it is done with so little notice, if we consider how very *quick* the actions of the mind are performed; for as itself is thought to take up no space, to have no extension, so its actions seem to require no time, but many of them seem to be crowded into an instant. I speak this in comparison to the actions of the body. Any one may easily observe this in his own thoughts, who will take the pains to reflect on them. How, as it were in an instant, do our minds with one glance see all the parts of a demonstration, which may very well be called a long one, if we consider the time it will require to put it into words, and step by step show it to another? Secondly, we shall not be so much surprised that this is done in us with so little notice, if we consider how the facility which we get of doing things by a custom of doing makes them often pass in us without our notice. *Habits*, especially such as are begun very early, come at last to produce actions in us, which often escape our observations. How frequently do we in a day cover our eyes with our eye-lids, without perceiving that we are at all in the dark? Men that have by custom got the use of a bye-word, do almost in every sentence pronounce sounds, which, though taken notice of by others, they themselves neither hear nor observe; and, therefore, it is not so strange, that our mind should often change the idea of its *sensation* into that of its *judgment*, and make one serve only to excite the other, without our taking notice of it."—(LOCKE's *Works*, Vol. I. p. 123, *et seq.*)

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[*] Mr Locke might, however, have remarked something very *similar* to it in the perceptions of the ear; a very large proportion of its appropriate objects being rather *judged of* than actually *perceived*. In the rapidity (for example) of common conversation, how many syllables, and even words, escape the notice of the most attentive hearer; which syllables and words are so quickly supplied from the relation which they bear to the rest of the sentence, that it is quite impossible to distinguish between the audible and the inaudible sounds! A very palpable instance of this occurs in the difficulty experienced by the most acute ear in catching *proper names* or arithmetical sums, or words borrowed from unknown tongues, the first time they are pronounced.

up a considerable space; I thence form a judgment or conclusion, that the object I see beyond them is at a great distance. Again, when an object appears faint and small, which, at a near distance, I have experienced to make a vigorous and large appearance, I instantly conclude it to be far off. And this, 'tis evident, is the result of *experience*, without which, from the faintness and littleness, I should not have inferred anything concerning the distance of objects.

" But when an object is placed at *so near a distance*, as that the interval between the eyes bears any sensible proportion to it, it is the received opinion that the two optic axes, concurring at the object, do there make an angle, by means of which, according as it is greater or less, the object is perceived to be nearer or farther off.

" There is another way mentioned by the optic writers, whereby they will have us judge of those distances, in respect of which the breadth of the pupil hath any sensible bigness; and that is, the greater or less divergency of the rays, which, issuing from the visible point, do fall on the pupil; that point being judged nearest, which is seen by most diverging rays, and that remoter, which is seen by less diverging rays."

These (according to Berkeley) are the " common and current accounts" given by *mathematicians* of our perceiving *near distances* by sight. He then proceeds to show, that they are unsatisfactory; and that it is necessary, for the solution of this problem, to avail ourselves of principles borrowed from a higher philosophy: After which, he explains, in detail, his own theory concerning the *ideas (sensations)* which, by experience, become *signs* of distance;[1] or (to use his own phraseology) " by which distance is *suggested*[2] to the mind." The result of the whole is, that, " a man born blind, being made to see, would not at first have any idea of distance by sight. *The sun and stars, the remotest objects as well as the nearest, would all seem to be in his Eye, or rather in his Mind.*"[3]

From this quotation it appears, that, before Berkeley's time, philosophers had advanced greatly beyond the point at which Aristotle stopped, and towards which Condillac, in his first publication, made a retrograde movement. Of this progress some of the chief steps may be traced as early as the twelfth century in the Optics of Alhazen;[4] and they may be perceived still more clearly and distinctly in various optical writers since the revival of letters; particularly in the *Optica Promota* of James Gregory.[5] Father Malebranche went still farther, and even anticipated some of the *metaphysical* reasonings of Berkeley concerning the means by which experience enables us to judge of the distances of *near* objects. In proof of this, it is sufficient to mention the explanation he gives of the manner in which a comparison of the perceptions of sight and of touch teaches us gradually to estimate by the eye the distances of all those objects which are within reach of our hands, or of which we are accustomed to measure the distance, by walking over the intermediate ground.

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[1] For assisting persons unaccustomed to metaphysical studies to enter into the spirit and scope of Berkeley's *Theory*, the best illustration I know of is furnished by the phenomena of the *Phantasmagoria*. It is sufficient to hint at this application of these phenomena, to those who know anything of the subject.

[2] The word *suggest* is much used by Berkeley, in this appropriate and technical sense, not only in his *Theory of Vision*, but in his *Principles of Human Knowledge*, and in his *Minute Philosopher*. It expresses, indeed, the cardinal principle on which his *Theory of Vision* hinges; and is now so incorporated with some of our best metaphysical speculations, that one cannot easily conceive how the use of it was so long dispensed with. Locke (in the passage quoted in the Note, p. 107.) uses the word *excite* for the same purpose; but it seems to imply an hypothesis concerning the *mechanism* of the mind, and by no means expresses the fact in question with the same force and precision.

It is remarkable, that Dr Reid should have thought it incumbent on him to apologise for introducing into philosophy a word so familiar to every person conversant with Berkeley's works. " I beg leave to make use of the word *suggestion*, because I know not one more proper to express a power of the mind, which seems entirely to have escaped the notice of philosophers, and to which we owe many of our simple notions which are neither impressions nor ideas, as well as many original principles of belief. I shall endeavour to explain, by an example, what I understand by this word. We all know that a certain kind of sound *suggests* immediately to the mind a coach passing in the street; and not only produces the imagination, but the belief, that a coach is passing. Yet there is no comparing of ideas, no perception of agreements or disagreements to produce this belief; nor is there the least similitude between the sound we hear, and the coach we imagine and believe to be passing."

So far Dr Reid's use of the word coincides exactly with that of Berkeley; but the former will be found to annex to it a meaning more extensive than the latter, by employing it to comprehend not only those *intimations* which are the result of experience and habit; but another class of *intimations* (quite overlooked by Berkeley), those which result from the original frame of the human mind.—(See REID's *Inquiry*, chap. ii. sect. 7.)

[3] I request the attention of my readers to this last sentence, as I have little doubt that the fact here stated gave rise to the theory which Berkeley afterwards adopted, concerning the non-existence of the material world. It is not, indeed, surprising that a conclusion, so very curious with respect to the objects of sight, should have been, in the first ardour of discovery, too hastily extended to those qualities also which are the appropriate objects of touch.

[4] Alhazen, Lib. ii. N N. 10. 12. 39.

[5] See the end of Prop. 28.

In rendering this justice to earlier writers, I have no wish to detract from the originality of Berkeley. With the single exception, indeed, of the passage in Malebranche which I have just referred to, and which it is more than probable was unknown to Berkeley when his theory first occurred to him,[1] I have ascribed to his predecessors nothing more than what he has himself explicitly acknowledged to belong to them. All that I wished to do was, to supply some links in the historical chain, which he has omitted.

The influence which this justly celebrated work has had, not only in perfecting the theory of optics, but in illustrating the astonishing effects of early habit on the mental phenomena in general, will sufficiently account to my intelligent readers for the length to which the foregoing observations upon it have extended.

Next in point of importance to Berkeley's New Theory of Vision, which I regard as by far the most solid basis of his philosophical fame, may be ranked his speculations concerning the Objects of General Terms, and his celebrated argument against the existence of the Material World. On both of these questions I have elsewhere explained my own ideas so fully, that it would be quite superfluous for me to resume the consideration of them here.[2] In neither instance are his reasonings so entirely original as has been commonly supposed. In the former, they coincide in substance, although with immense improvements in the form, with those of the scholastic nominalists, as revived and modified by Hobbes and Leibnitz. In the latter instance, they amount to little more than an ingenious and elegant development of some principles of Malebranche, pushed to certain paradoxical but obvious consequences, of which Malebranche, though unwilling to avow them, appears to have been fully aware. These consequences, too, had been previously pointed out by Mr Norris, a very learned divine of the church of England, whose name has unaccountably failed in obtaining that distinction to which his acuteness as a logician, and his boldness as a theorist, justly entitled him ![3]

The great object of Berkeley, in maintaining his system of idealism, it may be proper to remark in passing, was to cut up by the roots the scheme of materialism. "Matter (he tells us himself) being once *expelled out of nature*, drags with it so many sceptical and impious notions. * * * * Without it your Epicureans, Hobbists, and the like, have not even the shadow of a pretence, but become the most cheap and easy triumph in the world."

Not satisfied with addressing these abstract speculations to the learned, Berkeley conceived them to be of such moment to human happiness, that he resolved to bring them, if possible, within the reach of a wider circle of readers, by throwing them into the more popular and amusing form of dialogues.[4] The skill with which he has executed this very difficult and unpromising task cannot be too much admired. The characters of his speakers are strongly marked and happily contrasted; the illustrations exhibit a singular combination of logical subtlety and of poetical invention; and the style, while it everywhere abounds with the rich, yet sober colourings of the author's fancy, is perhaps superior, in point of purity and of grammatical correctness, to any English composition of an earlier date.[1]

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[1] Berkeley's *Theory* was published when he was only twenty-five ; an age when it can scarcely be supposed that his metaphysical reading had been very extensive.

[2] See *Philosophical Essays*.

[3] Another very acute metaphysician of the same church (Arthur Collier, author of a *Demonstration of the Non-existence and Impossibility of an External World*) has met with still greater injustice. His name is not to be found in any of our Biographical Dictionaries. In point of date, his publication is some years posterior to that of Norris, and therefore it does not possess the same claims to originality ; but it is far superior to it in logical closeness and precision, and is not obscured to the same degree with the mystical theology which Norris (after the example of Malebranche) connected with the scheme of Idealism. Indeed, when compared with the writings of Berkeley himself, it yields to them less in force of argument, than in composition and variety of illustration. The title of Collier's book is "*Clavis Universalis*, or a New Inquiry after Truth, being a Demonstration, &c. &c. By Arthur Collier, Rector of Langford Magna, near Sarum. (Lond. printed for Robert Gosling, at the Mitre and Crown, against St Dunstan's Church, Fleet Street, 1713.)" The motto prefixed by Collier to his work is from Malebranche, and is strongly characteristical both of the English and French *Inquirer after Truth*. "Vulgi assensus et approbatio circa materiam difficilem est certum argumentum falsitatis istius opinionis cui assentitur." —(*Maleb. De Inquir. Verit.* Lib. iii. p. 194.) See Note S S.

[4] I allude here chiefly to *Alciphron*, or the *Minute Philosopher ;* for as to the dialogues between *Hylas* and *Philonous*, they aspire to no higher merit than that of the common dialogues between A and B ; being merely a compendious way of stating and of obviating the principal objections which the author anticipated to his opinions.

The impression produced in England by Berkeley's Idealism was not so great as might have been expected; but the novelty of his paradoxes attracted very powerfully the attention of a set of young men who were then prosecuting their studies at Edinburgh, and who formed themselves into a society for the express purpose of soliciting from the author an explanation of some parts of his theory which seemed to them obscurely or equivocally expressed. To this correspondence the amiable and excellent prelate appears to have given every encouragement; and I have been told by the best authority, that he was accustomed to say, that his reasonings had been nowhere better understood than by this club of young Scotsmen.[2] The ingenious Dr Wallace, author of the *Discourse on the Numbers of Mankind*, was one of the leading members; and with him were associated several other individuals whose names are now well known and honourably distinguished in the learned world. Mr Hume's *Treatise of Human Nature*, which was published in 1739, affords sufficient evidence of the deep impression which Berkeley's writings had left upon his mind; and to this juvenile essay of Mr Hume's may be traced the origin of the most important metaphysical works which Scotland has since produced.

It is not, however, my intention to prosecute farther, at present, the history of Scottish philosophy. The subject may be more conveniently, and I hope advantageously resumed, after a slight review of the speculations of some English and French writers, who, while they professed a general acquiescence in the doctrines of Locke, have attempted to modify his fundamental principles in a manner totally inconsistent with the views of their master. The remarks which I mean to offer on the modern French school will afford me, at the same time, a convenient opportunity of introducing some strictures on the metaphysical systems which have of late prevailed in other parts of the Continent.

SECTION V.

Hartleian School.

The English writers to whom I have alluded in the last paragraph, I shall distinguish by the title of Dr Hartley's School; for although I by no means consider this person as the first author of any of the theories commonly ascribed to him (the seeds of all of them having been previously sown in the university where he was educated), it was nevertheless reserved for him to combine them together, and to exhibit them to the world in the imposing form of a system.

Among the immediate predecessors of Hartley, Dr Law, afterwards Bishop of Carlisle, seems to have been chiefly instrumental in preparing the way for a schism among Locke's disciples. The name of Law was first known to the public by an excellent translation, accompanied by many learned, and some very judicious notes, of Archbishop King's work on the Origin of Evil; a work of which the great object was to combat the Optimism of Leibnitz, and the Manicheism imputed to Bayle. In making this work more generally known, the translator certainly rendered a most acceptable and important service to the world, and, indeed, it is upon this ground that his best claim to literary distinction is still founded.[1] In his own original speculations, he is weak, paradoxical, and oracular;[2] affecting, on all occasions, the most profound veneration for the opinions of Locke, but much more apt to attach himself to the errors and oversights of that great man, than to enter into the general spirit of his metaphysical philosophy.

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[1] Dr Warton, after bestowing high praise on the *Minute Philosopher*, excepts from his encomium " those passages in the fourth dialogue, where the author has introduced his fanciful and whimsical opinions about vision."—(*Essay on the Writings and Genius of Pope*, Vol. II. p. 264.)—If I were called on to point out the most ingenious and original part of the whole work, it would be the argument contained in the passages here so contemptuously alluded to by this learned and (on all questions of taste) most respectable critic.

[2] The authority I here allude to is that of my old friend and preceptor, Dr John Stevenson, who was himself a member of the *Rankenian* Club, and who was accustomed for many years to mention this fact in his *Academical Prelections*.

To this translation, Dr Law prefixed a Dissertation concerning the Fundamental Principle of Virtue, by the Reverend Mr Gay: a performance of considerable ingenuity, but which would now be entitled to little notice, were it not for the influence it appears to have had in suggesting to Dr Hartley the possibility of accounting for all our intellectual pleasures and pains, by the single principle of the Association of Ideas. We are informed by Dr Hartley himself, that it was in consequence of hearing some account of the contents of this dissertation, he was first led to engage in those inquiries which produced his celebrated *Theory of Human Nature.*

The other principle on which this theory proceeds (that of the vibrations and vibratiuncles in the medullary substance of the brain) is also of Cambridge origin. It occurs in the form of a query in Sir Isaac Newton's *Optics;* and a distinct allusion to it, as a principle likely to throw new light on the phenomena of mind, is to be found in the concluding sentence of Smith's *Harmonies.*

Very nearly about the time when Hartley's *Theory* appeared, Charles Bonnet of Geneva published some speculations of his own, proceeding almost exactly on the same assumptions. Both writers speak of vibrations *(ébranlemens)* in the nerves; and both of them have recourse to a subtle and elastic ether, co-operating with the nerves in carrying on the communication between soul and body.[3] This fluid Bonnet conceived to be contained in the nerves, in a manner analogous to that in which the electric fluid is contained in the solid bodies which conduct it; differing in this respect from the Cartesians as well as from the ancient physiologists, who considered the nerves as hollow tubes or pipes, within which the animal spirits were included. It is to this elastic ether that Bonnet ascribes the vibrations of which he supposes the nerves to be susceptible; for the nerves themselves (he justly observes) have no resemblance to the stretched cords of a musical instrument.[4]

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[1] King's argument in proof of the prevalence in this world, both of Natural and Moral Good, over the corresponding Evils, has been much and deservedly admired; nor are Law's Notes upon this head entitled to less praise. Indeed, it is in this part of the work that both the author and his commentator appear, in my opinion, to the greatest advantage.

[2] As instances of this I need only refer to the *first* and *third* of his Notes on King; the former of which relates to the word *substance;* and the latter to the dispute between Clarke and Leibnitz concerning *space.* His reasonings on both subjects are obscured by an affected use of hard and unmeaning words, ill becoming so devoted an admirer of Locke. The same remark may be extended to an *Inquiry into the Ideas of Space and Time*, published by Dr Law in 1734.

The result of Law's speculations on Space and Time is thus stated by himself: "That our ideas of them do not imply any external *ideatum* or *objective* reality; that these ideas (as well as those of *infinity* and *number*) are *universal* or *abstract* ideas, existing under that *formality* no where but in the mind; nor affording a proof of any thing, but of the power which the mind has to form them."—(LAW'S *Trans. of King*, p. 7. 4th edit.) This language, as we shall afterwards see, approaches very nearly to that lately introduced by Kant. Dr Law's favourite author might have cautioned him against such jargon. (See *Essay on the Human Understanding*, Book II. Chap. xiii. § 17, 18.)

The absurd application of the scholastic word *substance* to empty space; an absurdity in which the powerful mind of Gravesande acquiesced many years after the publication of the *Essay on Human Understanding*, has probably contributed not a little to force some authors into the opposite extreme of maintaining, with Leibnitz and Dr Law, that our idea of space does not imply any external *ideatum* or objective reality. Gravesande's words are these: "Substantiæ sunt aut cogitantes, aut non cogitantes; cogitantes duas novimus, Deum et Mentem nostram: præter has et alias dari in dubium non revocamus. Duæ etiam substantiæ, quæ non cogitant, nobis notæ sunt Spatium et Corpus."—GRAVESANDE, *Introd. ad Philosophiam*, § 19.

[3] *Essai Analytique de l'Ame*, Chap. v. See also the additional notes on the first chapter of the seventh part of the *Contemplation de la Nature.*

[4] Mais les nerfs sont mous, ils ne sont point tendus comme les cordes d'un instrument; les objets y exciteroient-ils donc

Hartley's *Theory* differs in one respect from this, as he speaks of vibrations and vibratiuncles in the medullary substance of the brain and nerves. He agrees, however, with Bonnet, in thinking, that to these vibrations in the nerves the co-operation of the ether is essentially necessary; and, therefore, at bottom the two hypotheses may be regarded as in substance the same. As to the trifling shade of difference between them, the advantage seems to me to be in favour of Bonnet.

Nor was it only in their Physiological Theories concerning the nature of the union between soul and body, that these two philosophers agreed. On all the great articles of metaphysical theology, the coincidence between their conclusions is truly astonishing. Both held the doctrine of Necessity in its fullest extent; and both combined with it a vein of mystical devotion, setting at defiance the creeds of all established churches. The intentions of both are allowed, by those who best knew them, to have been eminently pure and worthy; but it cannot be said of either, that his metaphysical writings have contributed much to the instruction or to the improvement of the public. On the contrary, they have been instrumental in spreading a set of speculative tenets very nearly allied to that sentimental and fanatical modification of Spinozism, which, for many years past, has prevailed so much, and produced such mischievous effects in some parts of Germany.[1]

But it is chiefly by his application of the associating principle to account for all the mental phenomena, that Hartley is known to the world; and upon this I have nothing to add to what I have already stated in another work.—*(Phil. Essays*, Essay IV.)—His Theory seems to be already fast passing into oblivion; the temporary popularity which it enjoyed in this country having, in a great measure, ceased with the life of its zealous and indefatigable apostle Dr Priestley.[2]

It would be unfair, however, to the translator of Archbishop King, to identify his opinions with those of Hartley and Priestley. The zeal with which he contends for man's free agency is sufficient, of itself, to draw a strong line of distinction between his Ethical System and theirs.—(See his Notes on King, *passim.*)—But I must be allowed to say of him, that the general scope of his writings tends, in common with that of the two other metaphysicians, to depreciate the evidences of Natural Religion, and more especially to depreciate the evidences which the light of nature affords of a life to come;—

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les vibrations analogues à celle d'une corde pincée? Ces vibrations se communiqueroient-elles à l'instant au siège de l'âme? La chose paroit difficile à conçevoir. Mais si l'on admet dans les nerfs un fluide dont la subtilité et l'élasticité approche de celle de la lumière ou de l'éther, on expliquera facilement par le secours de ce fluide, et la célérité avec laquelle les impressions se communiquent à l'âme, et celle avec laquelle l'âme éxécute tant d'opérations différentes."—*(Essai Anal.* Chap. v.)

"Au reste, les physiologistes qui avoient cru que les filets nerveux étoient solides, avoient cédé à des apparences trompeuses. Ils vouloient d'ailleurs faire osciller les nerfs pour rendre raison des sensations, et les nerfs ne peuvent osciller. Ils sont mous, et nullement élastiques. Un nerf coupé ne se retire point. C'est le fluide invisible que les nerfs renferment, qui est doué de cette élasticité qu'on leur attribuoit, et d'une plus grande élasticité encore."—*(Contemp. de la Nature*, VII. Partie, Chap. i. Note at the end of the chapter.)

M. Quesnai, the celebrated author of the *Economical System*, has expressed himself to the same purpose concerning the supposed vibrations of the nerves: "Plusieurs physiciens ont pensé que le seul ébranlement des nerfs, causé par les objets qui touchent les organes des corps, suffit pour occasioner le mouvement et le sentiment dans les parties où les nerfs sont ébranlés. Ils se representent les nerfs comme des cordes fort tendus, qu'un léger contact met en vibration dans toute leur étendue. Des philosophes, peu instruits en anatomie, ont pu se former un telle idée . . . . . . Mais cette tension qu'on suppose dans les nerfs, et qui les rend si susceptibles d'ébranlement et de vibration, est si grossièrement imaginée qu'il seroit ridicule de s'occuper sérieusement à la refuter." (*Econ. Animale*, sect. 3. c. 13.)

As this passage from Quesnai is quoted by Condillac, and sanctioned by his authority (*Traité des Animaux*, Chap. iii.), it would appear that the hypothesis which supposes the nerves to perform their functions by means of vibrations was going fast into discredit, both among the metaphysicians and the physiologists of France, at the very time when it was beginning to attract notice in England, in consequence of the visionary speculations of Hartley.

[1] In a letter which I received from Dr Parr, he mentions a treatise of Dr Hartley's which appeared about a year before the publication of his great work; to which it was meant by the author to serve as a precursor. Of this rare treatise I had never before heard. "You will be astonished to hear," says Dr Parr, "that in this book, instead of the doctrine of necessity, Hartley openly declares for the indifference of the will, as maintained by Archbishop King." We are told by Hartley himself that his notions upon necessity grew upon him while he was writing his observations upon man; but it is curious (as Dr Parr remarks), that in the course of a year, his opinions on so very essential a point should have undergone a complete change.

[2] Dr Priestley's opinion of the merits of Hartley's work is thus stated by himself:—"Something was done in this field of knowledge by Descartes, very much by Mr Locke, but most of all by Dr Hartley, who has thrown more useful light upon the theory of the mind, than Newton did upon the theory of the natural world."—*(Remarks on Reid, Beattie, and Oswald*, p. 2. London, 1774.)

"a doctrine equally necessary to comfort the weakness, and to support our lofty ideas of the grandeur of human nature;"[1] and of which it seems hard to confine exclusively the knowledge to that portion of mankind who have been favoured with the light of Revelation. The influence of the same fundamental error, arising, too, from the same mistaken idea, of thus strengthening the cause of Christianity, may be traced in various passages of the posthumous work of the late Bishop of Llandaff. It is wonderful that the reasonings of Clarke and of Butler did not teach these eminent men a sounder and more consistent logic; or, at least, open their eyes to the inevitable consequences of the rash concessions which they made to their adversaries.[2]

Among the disciples of Law, one illustrious exception to these remarks occurs in Dr Paley, whose treatise on Natural Theology is unquestionably the most instructive as well as interesting publication on that subject which has appeared in our times. As the book was intended for popular use, the author has wisely avoided, as much as possible, all metaphysical discussions; but I do not know that there exists any other work where the argument from *final causes* is placed in so great a variety of pleasing and striking points of view.

SECTION VI.

Condillac, and other French Metaphysicians of a later date.

WHILE Hartley and Bonnet were indulging their imagination in theorising concerning the nature of the union between soul and body, Condillac was attempting to draw the attention of his countrymen to the method of studying the phenomena of Mind recommended and exemplified by Locke.[3] Of the vanity of expecting to illustrate, by physiological conjectures, the manner in which the intercourse between the thinking principle and the external world is carried on, no philosopher seems ever to have been more completely aware; and, accordingly, he confines himself strictly, in all his researches concerning this intercourse, to an examination of the general laws by which it is regulated. There is, at the same time, a remarkable coincidence between some of his views and those of the other two writers. All of the three, while they profess the highest veneration for Locke, have abandoned his account of the origin of our ideas for that of Gassendi; and, by doing so, have, with the best intentions, furnished arms against those principles which it was their common aim to establish in the world.[1] It is much to be regretted, that by far the greater part of those French writers who have since speculated about the human mind, have acquired the whole of their knowledge of Locke's philosophy through this mistaken comment upon its fundamental principle. On this subject I have already exhausted all that I have to offer on the effect of Condillac's writings; and I flatter myself have sufficiently shown how widely his commentary differs from the text of his author. It is this commentary, however, which is now almost universally received on the Continent as the doctrine of Locke, and which may justly be regarded as the sheet-anchor of those systems which are commonly stigmatised in England with the appellation of French philosophy. Had Condillac been sufficiently aware of the consequences which have been deduced (and I must add *logically* deduced) from his account of the origin of our knowledge, I am persuaded, from his known candour and love of truth, that he would have been eager to acknowledge and to retract his error.

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[1] SMITH'S *Theory of Moral Sentiments*, 6th ed. Vol. I. pp. 325, 326.

Dr Law's doctrine of the sleep of the soul, to which his high station in the church could not fail to add much weight in the judgment of many, is, I believe, now universally adopted by the followers of Hartley and Priestley; the theory of vibrations being evidently inconsistent with the supposition of the soul's being able to exercise her powers in a separate state from the body.

[2] Without entering at all into the argument with Dr Law or his followers, it is sufficient here to mention, as an historical fact, their wide departure from the older lights of the English church, from Hooker downwards. "All religion," says Archbishop Tillotson, whom I select as an unexceptionable organ of their common sentiments, "is founded on right notions of God and his perfections, insomuch that Divine Revelation itself does suppose these for its foundations; and can signify nothing to us unless they be first known and believed; so that the principles of natural religion are the foundation of that which is revealed."—(Sermon 41.) "There is an intrinsical good and evil in things, and the reasons and respects of moral good and evil are fixed and immutable, eternal and indispensable. Nor do they speak safely who make the Divine will the rule of moral good and evil, as if there were nothing good or evil in its own nature antecedently to the will of God; but, that all things are therefore good and evil because God wills them to be so."—(Sermon 88.) "Natural religion is obedience to the natural law, and the performance of such duties as natural light, without any express and supernatural revelation, doth dictate to men. These lie at the bottom of all religion, and are the great fundamental duties which God requires of all mankind. These are the surest and most sacred of all other laws; those which God hath rivetted in our souls and written upon our hearts; and these are what we call moral duties, and most valued by God, which are of eternal and perpetual obligation, because they do naturally oblige, without any particular and express revelation from God; and these are the foundation of revealed and instituted religion; and all revealed religion does suppose them and build upon them."—Sermons 48. 49.

[3] It may appear to some unaccountable, that no notice should have been taken, in this Dissertation, of any French metaphysician during the long interval between Malebranche and Condillac. As an apology for this apparent omission, I beg leave to quote the words of an author intimately acquainted with the history of French literature and philosophy, and eminently qualified to appreciate the merits of those who have contributed to their progress. "If we except," says Mr Adam Smith, in a *Memoir* published in 1755, "the Meditations of Descartes, I know of nothing in the works of French writers which aspires at originality in morals or metaphysics; for the philosophy of Regius and that of Malebranche are nothing more than the meditations of Descartes unfolded with more art and refinement. But Hobbes, Locke, Dr Mandeville, Lord Shaftesbury, Dr Butler, Dr Clarke, and Mr Hutcheson, each in his own system, all different and all incompatible, have tried to be original, at least in some points. They have attempted to add something to the fund of observations col-

In this apparent simplification and generalisation of Locke's doctrine, there is, it must be acknowledged, something, at first sight, extremely seducing. It relieves the mind from the painful exercise of abstracted reflection, and amuses it with analogy and metaphor when it looked only for the severity of logical discussion. The clearness and simplicity of Condillac's style add to the force of this illusion, and flatter the reader with an agreeable idea of the powers of his own understanding, when he finds himself so easily conducted through the darkest labyrinths of metaphysical science. It is to this cause I would chiefly ascribe the great popularity of his works. They may be read with as little exertion of thought as a history or a novel; and it is only when we shut the book, and attempt to express in our own words the substance of what we have gained, that we have the mortification to see our supposed acquisitions vanish into air.

The philosophy of Condillac was, in a more peculiar manner, suited to the taste of his own country, where (according to Mad. de Stael) "few read a book but with a view to talk of it."[2] Among such a people, speculations which are addressed to the power of reflection can never expect to acquire the same popularity with theories expressed in a metaphorical lan-

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lected by their predecessors, and already the common property of mankind. This branch of science, which the English themselves neglect at present, appears to have been recently transported into France. I discover some traces of it not only in the *Encyclopédie*, but in the *Theory of Agreeable Sensations*, by M. de Pouilly; and much more in the late discourse of M. Rousseau, *On the Origin and Foundation of the Inequality of Ranks among Men*."

Although I perfectly agree with Mr Smith in his general remark on the sterility of invention among the French metaphysicians posterior to Descartes, when compared to those of England, I cannot pass over the foregoing quotation without expressing my surprise, 1*st*, To find the name of Malebranche (one of the highest in modern philosophy) degraded to a level with that of Regius; and, 2*dly*, To observe Mr Smith's silence with respect to Buffier and Condillac, while he mentions the author of the *Theory of Agreeable Sensations* as a metaphysician of original genius. Of the merits of Condillac, whose most important works were published several years before this paper of Mr Smith's, I am about to speak in the text; and those of Buffier I shall have occasion to mention in a subsequent part of this discourse. In the mean time, I shall only say of him, that I regard him as one of the most original as well as sound philosophers of whom the eighteenth century has to boast.

[1] Condillac's earliest work appeared three years before the publication of Hartley's *Theory*. It is entitled, "*Essai sur l'Origine des Connoissances Humaines. Ouvrage où l'on réduit à un seul principe tout ce qui concerne l'entendement humain.*" This *seul principe* is the association of ideas. The account which both authors give of the transformation of sensations into ideas is substantially the same.

[2] "En France, on ne lit guère un ouvrage que pour en parler."—(*Allemagne*, Tom. I. p. 292.) The same remark, I am much afraid, is becoming daily more and more applicable to our own island.

guage, and constantly recalling to the fancy the impressions of the external senses. The state of society in France, accordingly, is singularly unfavourable to the inductive philosophy of the human mind; and of this truth no proof more decisive can be produced, than the admiration with which the metaphysical writings of Condillac have been so long regarded.

On the other hand, it cannot be denied that Condillac has, in many instances, been eminently successful, both in observing and describing the mental phenomena; but, in such cases, he commonly follows Locke as his guide; and, wherever he trusts to his own judgment, he seldom fails to wander from his way. The best part of his works relates to the action and reaction of thought and language on each other, a subject which had been previously very profoundly treated by Locke, but which Condillac has had the merit of placing in many new and happy points of view. In various cases, his conclusions are pushed too far, and in others are expressed without due precision; but, on the whole, they form a most valuable accession to this important branch of logic; and (what not a little enhances their value) they have been instrumental in recommending the subject to the attention of other inquirers, still better qualified than their author to do it justice.

In the speculation, too, concerning the origin and the theoretical history of language, Condillac was one of the first who made any considerable advances; nor does it reflect any discredit on his ingenuity, that he has left some of the principal difficulties connected with the inquiry very imperfectly explained. The same subject was soon after taken up by Mr Smith, who, I think, it must be owned, has rather slurred over these difficulties, than attempted to remove them; an omission on his part the more remarkable, as a very specious and puzzling objection had been recently stated by Rousseau, not only to the theory of Condillac, but to all speculations which have for their object the solution of the same problem. "If language" (says Rousseau) "be the result of human convention, and if words be essential to the exercise of thought, language would appear to be necessary for the invention of language."[1]—"But" (continues the same author) "when, by means *which I cannot conceive*, our new grammarians began to extend their ideas, and to generalise their words, their ignorance must have confined them within very narrow bounds. . . . . How, for example, could they imagine or comprehend such words as matter, mind, substance, mode, figure, motion, since our philosophers, who have so long made use of them, scarcely understand them, and since the ideas attached to them, being purely metaphysical, can have no model in nature?"

"I stop at these first steps" (continues Rousseau), "and intreat my judges to pause, and consider the distance between the easiest part of language, the invention of physical substantives, and the power of expressing all the thoughts of man, so as to speak in public, and influence society. I entreat them to reflect upon the time and knowledge it must have required to discover numbers, abstract words, aorists, and all the tenses of verbs, particles, syntax, the art of connecting propositions and arguments, and how to form the whole logic of discourse. As for myself, alarmed at these multiplying difficulties, and convinced of the almost demonstrable impossibility of language having been formed and established by means merely human, I leave to others the discussion of the problem, 'Whether a society already formed was more necessary for the institution of language, or a language already invented for the establishment of society?'"[2]

Of the various difficulties here enumerated, *that* mentioned by Rousseau, in the last sentence, was plainly considered by him as the greatest of all; or rather as comprehending under it all the rest. But this difficulty arises merely from his own peculiar and paradoxical theory about the artificial origin of society; a theory which needs no refutation, but the short and luminous aphorism of Montesquieu, that "man is born in society, and there he remains." The other difficulties touched upon by Rousseau, in the former part of this quotation, are much more serious, and have never yet been removed in a manner completely satisfactory: And hence some very ingenious writers have been led to conclude, that language could not possibly have been the work of human invention. This argument has been lately urged with much acuteness and plausibility by Dr Magee of Dublin, and by M. de Bonald of Paris.[1] It may, however, be reasonably questioned, if these philosophers would not have reasoned more logically, had they contented themselves with merely affirming, that the problem has not yet been solved, without going so far as to pronounce it to be absolutely insolvable. For my own part, when I consider its extreme difficulty, and the short space of time during which it has engaged the attention of the learned, I am more disposed to wonder at the steps which have been already gained in the research, than at the number of *desiderata* which remain to employ the ingenuity of our successors. It is justly remarked by Dr Ferguson, that, "when language has attained to that perfection to which it arrives in the progress of society, the speculative mind, in comparing the first and the last stages of the progress, feels the same sort of amazement with a traveller, who, after rising insensibly on the slope of a hill, comes to look down from a precipice, to the summit of which he scarcely believes he could have ascended without supernatural aid."[2]

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[1] That men never could have invented an artificial language, if they had not possessed a natural language, is an observation of Dr Reid's; and it is this indisputable and self-evident truth which gives to Rousseau's remark that imposing plausibility, which, at first sight, dazzles and perplexes the judgment. I by no means say, that the former proposition affords a key to *all* the difficulties suggested by the latter; but it advances us at least one important step towards their solution.

[2] *Discours sur l'Origine et les Fondemens de l'Inégalité parmi les Hommes*

With respect to some of the difficulties pointed out by Rousseau and his commentators, it may be here remarked in passing (and the observation is equally applicable to various passages in Mr Smith's dissertation on the same subject), that the difficulty of explaining the theory of any of our intellectual operations affords no proof of any difficulty in applying that operation to its proper practical purpose; nor is the difficulty of explaining the metaphysical nature of any part of speech a proof, that, in its first origin, it implied any extraordinary effort of intellectual capacity. How many metaphysical difficulties might be raised about the mathematical notion of a *line?* And yet this notion is perfectly comprehended by every peasant, when he speaks of the distance between two places; or of the length, breadth, or height of his cottage. In like manner, although it may be difficult to give a satisfactory account of the origin and import of such words as *of* or *by*, we ought not to conclude, that the invention of them implied any metaphysical knowledge in the individual who first employed them.[1] Their import, we see, is fully understood by children of three or four years of age.

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[1] The same theory has been extended to the art of writing; but if *this* art was first taught to man by an express revelation from Heaven, what account can be given of its present state in the great empire of China? Is the mode of writing practised there of divine or of human origin?

[2] *Principles of Moral and Political Science*, Vol. I. p. 43. Edin. 1792. To this observation may be added, by way of comment, the following reflections of one of the most learned prelates of the English church:—"Man, we are told, had a language from the beginning; for he conversed with God, and gave to every animal its particular name. But how came man by language? He must either have had it from *inspiration*, ready formed from his Creator, or have *derived* it by the exertion of those faculties of the mind, which were implanted in him as a rational creature, from natural and external objects with which he was surrounded. Scripture is silent on the means by which it was acquired. We are not, therefore, warranted to affirm, that it was received by *inspiration*, and there is no internal evidence in language to lead us to such a supposition. On this side, then, of the question, we have nothing but uncertainty; but on a subject, the causes of which are so remote, nothing is more convenient than to refer them to *inspiration*, and to recur to that easy and comprehensive argument,

Διὸς δ᾽ ἐτελείετο βουλή·

that is, man enjoyed the great privilege of speech, which distinguished him at first, and still continues to distinguish him as a *rational* creature, so eminently from the brute creation, without exerting those *reasoning* faculties, by which he was in *other* respects enabled to raise himself so much above their level. Inspiration, then, seems to have been an argument adopted and made necessary by the difficulty of accounting for it otherwise; and the name of inspiration carries with it an awfulness, which forbids the unhallowed approach of inquisitive discussion."—(*Essay on the Study of Antiquities*, by Dr BURGESS, 2d edit. Oxford, 1782. Pp. 85, 86.)

It is farther remarked very sagaciously, and I think very decisively, by the same author, that "the supposition of man having received a language ready formed from his Creator, is *actually* inconsistent with the evidence of the origin of our ideas, which exists in language. For, as the origin of our ideas is to be traced in the words through which the ideas are conveyed, so the origin of language is referable to the source from whence our *(first)* ideas are derived, namely, *natural* and *external* objects."—(*Ibid.* pp. 83, 84.)

In this view of the History of Language I have been anticipated by Dr Ferguson. "Parts of speech" (says this profound and original writer), which, in speculation, cost the grammarian so much study, are, in practice, familiar to the vulgar. The rudest tribes, even the idiot and the insane, are possessed of them. They are soonest learned in childhood, insomuch that we must suppose human nature, in its lowest state, competent to the use of them; and, without the intervention of uncommon genius, mankind, in a succession of ages, qualified to accomplish in detail this amazing fabric of language, which, when raised to its height, appears so much above what could be ascribed to any simultaneous effort of the most sublime and comprehensive abilities."[2]

It is, however, less in tracing the first rudiments of speech, than in some collateral inquiries concerning the genius of different languages, that Condillac's ingenuity appears to advantage. Some of his observations, in particular, on the connection of natural signs with the growth of a systematical prosody, and on the imitative arts of the Greeks and Romans, as distinguished from those of the moderns, are new and curious; and are enlivened with a mixture of historical illustration, and of critical discussion, seldom to be met with among metaphysical writers.

But through all his researches, the radical error may, more or less, be traced, which lies at the bottom of his system;[3] and hence it is,

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[1] In this remark I had an eye to the following passage in Mr Smith's dissertation:—"It is worth while to observe, that those prepositions, which, in modern languages, hold the place of the ancient cases, are, of all others, the most general, and abstract, and metaphysical; *and, of consequence, would probably be the last inveuted.* Ask any man of common acuteness, what relation is expressed by the preposition *above?* He will readily answer, that of *superiority.* By the preposition *below?* He will as quickly reply, that of *inferiority.* But ask him what relation is expressed by the preposition *of?* and, if he has not beforehand employed his thoughts a good deal upon these subjects, you may safely allow him a week to consider of his answer."

[2] The following judicious reflections, with which M Raynouard concludes the introduction to his *Elémeus de la Langue Romane*, may serve to illustrate some of the above observations. The modification of an existing language is, I acknowledge, a thing much less wonderful than the formation of a language entirely new; but the processes of thought, it is reasonable to think, are, in both cases, of the same kind; and the consideration of the one is at least a step gained towards the elucidation of the other.

"La langue Romane est peut-être la seule à la formation de laquelle il soit permis de remonter ainsi, pour découvrir et expliquer le secret de son industrieux mécanisme. . . . J'ose dire que l'esprit philosophique, consulté sur le choix des moyens qui devraient épargner à l'ignorance beaucoup d'études penibles et fastidieux, n'eut pas été aussi heureux que l'ignorance elle-même; il est vrai qu'elle avoit deux grands maîtres; la NÉCESSITÉ et le TEMS.

"En considerant à quelle époque d'ignorance et de barbarie s'est formé et perfectionné ce nouvel idiôme, d'après des principes indiqués seulement par l'analogie et l'euphonie, on se dira peut-être comme je me le suis dit; l'homme porte en soi-même les principes d'une logique naturelle, d'un instinct regulateur, que nous admirons quelquefois dans les enfans. Oui, la Providence nous a dôté de la faculté indestructible et des moyens ingenieux d'exprimer, de communiquer, d'éterniser par la parole, et par les signes permanens où elle se reproduit, cette pensée qui est l'un de nos plus beaux attributs, et qui nous distingue si éminemment et si avantageusement dans l'ordre de la creation."—(*Elémens de la Grammaire de la Langue Romaue avant l'An.* 1000. Pp. 104, 105. A Paris, 1816.)

In the theoretical history of language, it is more than probable, that some steps will remain to exercise the ingenuity of our latest posterity. Nor will this appear surprising, when we consider how impossible it is for us to judge, from our own experience, of the intellectual processes which pass in the minds of savages. Some instincts, we know, possessed both by them and by infants (that of imitation, for example, and the use of natural signs), disappear in by far the greater number of individuals, almost entirely in the maturity of their reason. It does not seem at all improbable, that other instincts connected with the invention of speech, may be confined to that state of the intellectual powers which requires their guidance: nor is it quite impossible, that some latent capacities of the understanding may be evolved by the pressure of necessity. The facility with which infants surmount so many grammatical and metaphysical difficulties, seems to me to add much weight to these conjectures.

In tracing the first steps of the invention of language, it ought never to be forgotten, that we undertake a task more similar than might at first be supposed, to that of tracing the first operations of the infant mind. In both cases, we are apt to attempt an explanation from reason alone, of what requires the co-operation of very different principles. To trace the theoretical history of geometry, in which we know for certain, that all the transitions have depended on *reasoning* alone, is a problem which has not yet been completely solved. Nor has even any satisfactory account been hitherto given of the experimental steps by which men were gradually led to the use of iron. And yet how simple are these problems, when compared with that relating to the origin and progress of language!

[3] A remarkable instance of this occurs in that part of Condillac's *Cours d'Etude*, where he treats of the art of writing: "Vous savez, Monseigneur, comment les mêmes noms ont été transportés des objets qui tombent sous les sens à ceux qui les échappent. Vous avez remarqué, qu'il y en a qui sont encore en usage dans l'un et l'autre acceptation, et qu'il y en a qui sont devenus les noms propres des choses, dont ils avoient d'abord été les signes figurés.

"Les premiers, tel que le *mouvemcnt* de l'âme, son *penchant*, sa *réflexion*, donnent un corps à des choses qui n'en ont pas. Les seconds, tels que la *pensée*, la *volonté*, le *desir*, ne peignent plus rien, et laissent aux idées abstraites cette spiritualité qui les dérobe aux sens. Mais si le langage doit être l'image de nos pensées, on a perdu beaucoup, lorsqu' oubliant la pre-

that, with all his skill as a writer, he never elevates the imagination, or touches the heart. That he wrote with the best intentions, we have satisfactory evidence; and yet hardly a philosopher can be named, whose theories have had more influence in misleading the opinions of his contemporaries.[1] In France, he very early attained to a rank and authority not inferior to those which have been so long and so deservedly assigned to Locke in England; and even in this country, his works have been more generally read and admired, than those of any foreign metaphysician of an equally recent date.

The very general sketches to which I am here obliged to confine myself, do not allow me to take notice of various contributions to metaphysical science, which are to be collected from writers professedly intent upon other subjects. I must not, however, pass over in silence the name of Buffon, who, in the midst of those magnificent views of external nature, which the peculiar character of his eloquence fitted him so admirably to delineate, has frequently indulged himself in ingenious discussions concerning the faculties both of men and of brutes. His subject, indeed, led his attention chiefly to man, considered as an animal; but the peculiarities which the human race exhibit in their physical condition, and the manifest reference which these bear to their superior rank in the creation, unavoidably engaged him in speculations of a higher aim, and of a deeper interest. In prosecuting these, he has been accused (and perhaps with some justice) of ascribing too much to the effects of bodily organisation on the intellectual powers; but he leads his reader in so pleasing a manner from matter to mind, that I have no doubt he has attracted the curiosity of many to metaphysical inquiries, who would never otherwise have thought of them. In his theories concerning the nature of the brutes, he has been commonly considered as leaning to the opinion of Descartes; but I cannot help thinking, without any good reason. Some of his ideas on the complicated operations of insects appear to me just and satisfactory; and while they account for the phenomena, without ascribing to the animal any deep or comprehensive knowledge, are far from degrading him to an insentient and unconscious machine.

In his account of the process by which the use of our external senses (particularly that of sight) is acquired, Buffon has in general follow-

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mière signification des mots, on a éffacé jusqu'au traits qu'ils donnoient aux idées. Toutes les langues sont en cela plus ou moins défectueuses, toutes aussi ont des tableaux plus ou moins conservés."—(*Cours d'Etude*, Tome II. p. 212. à Parme, 1775.)

Condillac enlarges on this point at considerable length; endeavouring to show, that whenever we lose sight of the analogical origin of a figurative word, we become insensible to one of the chief beauties of language. "In the word *examen*, for example, a Frenchman perceives only the proper name of one of our mental operations. A Roman attached to it the same idea, and received over and above the image of weighing and balancing. The case is the same with the words *âme* and *anima; pensée* and *cogitatio*.

In this view of the subject, Condillac plainly proceeded on his favourite principle, that all our notions of our mental operations are compounded of sensible images. Whereas the fact is, that the only just notions we can form of the powers of the mind are obtained by abstracting from the qualities and laws of the material world. In proportion, therefore, as the analogical origin of a figurative word disappears, it becomes a fitter instrument of metaphysical thought and reasoning.—(See *Philosophical Essays*, Part I. Essay V. Chap. iii.)

[1] A late writer (M. de Bonald), whose philosophical opinions, in general, agree nearly with those of La Harpe, has, however, appreciated very differently, and, in my judgment, much more sagaciously, the merits of Condillac: "Condillac a eu sur l'esprit philosophique du dernier siècle, l'influence que Voltaire à prise sur l'esprit religieux, et J. J. Rousseau sur les opinions politiques. Condillac a mis de la séchéresse et de la minutie dans les esprits; Voltaire du penchant à la raillerie et à la frivolité; Rousseau les a rendus chagrins et mécontens . . . . Condillac a encore plus faussé l'esprit de la nation, parce que sa doctrine etoit enseignée dans les premières études à des jeunes gens qui n'avoient encore lu ni Rousseau ni Voltaire, et que la manière de raisonner et la direction philosophique de l'esprit s'éténdent à tout."—(*Recherches Phil.* Tome I. pp. 187, 188.)

The following criticism on the supposed perspicuity of Condillac's style is so just and philosophical, that I cannot refrain from giving it a place here: Condillac est, ou paroit être, clair et méthodique; mais il faut prendre garde que la clarté des pensées, comme la transparence des objets physiques, peut tenir d'un défaut de profondeur, et que la méthode dans les écrits, qui suppose la patience de l'esprit, n'en prouve pas toujours la justesse; et moins encore la fécondité. Il y a aussi une clarté de style en quelque sorte toute materielle, qui n'est pas incompatible avec l'obscurité dans les idées. Rien de plus facile à entendre que les mots de *sensations transformées* dont Condillac s'est servi, parce que ces mots ne parlent qu'à l'imagination, qui se figure à volonté des transformations et des changemens. Mais cette transformation, appliquée aux operations de l'esprit, n'est qu'un mot vide de sens; et Condillac lui-même auroit été bien embarrassé d'en donner une explication satisfaisante. Ce philosophe me paroit plus heureux dans ses apperçus que dans ses demonstrations: La route de la vérité semble quelquefois s'ouvrir devant lui, mais retenu par la circonspection naturelle à un esprit sans chaleur, et intimidé par la faiblesse de son propre système, il n'ose s'y engager."—(*Ibid.* Tome I. pp. 33. 34.)

ed the principles of Berkeley; and, notwithstanding some important mistakes which have escaped him in his applications of these principles, I do not know that there is anywhere to be found so pleasing or so popular an exposition of the theory of vision. Nothing certainly was ever more finely imagined, than the recital which he puts into the mouth of our first parent, of the gradual steps by which he learned the use of his perceptive organs; and although there are various parts of it which will not bear the test of a rigorous examination, it is impossible to read it without sharing in that admiration, with which we are told the author himself always regarded this favourite effusion of his eloquence.

Nor are these the only instances in which Buffon has discovered the powers of a metaphysician. His thoughts on probabilities (a subject widely removed from his favourite studies) afford a proof how strongly some metaphysical questions had laid hold of his curiosity, and what new lights he was qualified to throw on them, if he had allowed them to occupy more of his attention.[1] In his observations, too, on the peculiar nature of mathematical evidence, he has struck into a train of the soundest thinking, in which he has been very generally followed by our later logicians.[2] Some particular expressions in the passage I refer to are exceptionable; but his remarks on what he calls *Vérités de Definition* are just and important; nor do I remember any modern writer, of an earlier date, who has touched on the same argument. Plato, indeed, and after him Proclus, had called the definitions of geometry *Hypotheses;* an expression which may be considered as involving the doctrine which Buffon and his successors have more fully unfolded.

What the opinions of Buffon were on those essential questions, which were then in dispute among the French philosophers, his writings do not furnish the means of judging with certainty. In his theory of *Organic Molecules*, and of *Internal Moulds*, he has been accused of entertaining views not very different from those of the ancient atomists; nor would it perhaps be easy to repel the charge, if we were not able to oppose to this wild and unintelligible hypothesis the noble and elevating strain, which in general so peculiarly characterises his descriptions of nature. The eloquence of some of the finest passages in his works has manifestly been inspired by the same sentiment which dictated to one of his favourite authors the following just and pathetic reflection:—" Le spectacle de la nature, si vivant, si animé pour ceux qui reconnoissent un Dieu, est mort aux yeux de l'athée, et dans cette grande harmonie des êtres où tout parle de Dieu d'une voix si douce, il n'aperçoit qu'un silence éternel."[3]

I have already mentioned the strong bias towards materialism which the authors of the *Encyclopédie* derived from Condillac's comments upon Locke. These comments they seem to have received entirely upon credit, without ever being at pains to compare them with the original. Had D'Alembert exercised freely his own judgment, no person was more likely to have perceived their complete futility; and, in fact, he has thrown out various observations which strike at their very root. Notwithstanding, however, these occasional glimpses of light, he invariably reverts to the same error, and has once and again repeated it in terms as strong as Condillac or Gassendi.

The author who pushed this account of the origin of our knowledge to the most extraordinary and offensive consequences, was Helvetius. His book, *De l'Esprit*, is said to have been com-

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[1] See his *Essai d'Arithmétique Morale.*

[2] See the First Discourse prefixed to his Natural History, towards the end.

[3] Rousseau.—In a work by Hérault de Sechelles (entitled *Voyages à Montbar, contenant des details très intéressans sur le caractère, la personne, et les écrits de Buffon*, Paris, 1801), a very different idea of his religious creed is given from that which I have ascribed to him; but, in direct opposition to this statement, we have a letter, dictated by Buffon, on his death-bed, to Madame Necker, in return for a present of her husband's book, *On the Importance of Religious Opinions.* The letter (we are told) is in the hand-writing of Buffon's son, who describes his father as then too weak to hold the pen.—(*Mélanges extraits des Manuscrits de Madame Necker.* 3 Vols. Paris, 1788.)

The sublime address to the Supreme Being, with which Buffon closes his reflections on the calamities of war, seems to breathe the very soul of Fenelon. " Grand Dieu! dont la seule présence soutient la nature et maintient l'harmonie des loix de l'univers," &c. &c. &c

posed of materials collected from the conversations of the society in which he habitually lived; and it has accordingly been quoted as an authentic record of the ideas then in fashion among the wits of Paris. The unconnected and desultory composition of the work certainly furnishes some intrinsic evidence of the truth of this anecdote.

According to Helvetius, as all our ideas are derived from the external senses,[1] the causes of the inferiority of the souls of brutes to those of men, are to be sought for in the difference between them with respect to bodily organisation. In illustration of this remark he reasons as follows:—

" 1. The feet of all quadrupeds terminate either in horn, as those of the ox and the deer; or in nails, as those of the dog and the wolf; or in claws, as those of the lion and the cat. This peculiar organisation of the feet of these animals deprives them not only of the sense of touch, considered as a channel of information with respect to external objects, but also of the dexterity requisite for the practice of the mechanical arts.

" 2. The life of animals, in general, being of a shorter duration than that of man, does not permit them to make so many observations, or to acquire so many ideas.

" 3. Animals being better armed and better clothed by nature than the human species, have fewer wants, and consequently fewer motives to stimulate or to exercise their invention. If the voracious animals are more cunning than others, it is because hunger, ever inventive, inspires them with the art of stratagems to surprise their prey.

" 4. The lower animals compose a society that flies from man, who, by the assistance of weapons made by himself, is become formidable to the strongest amongst them.

" 5. Man is the most prolific and versatile animal upon earth. He is born and lives in every climate; while many of the other animals, as the lion, the elephant, and the rhinoceros, are found only in a certain latitude. And the more any species of animals capable of making observations is multiplied, the more ideas and the greater ingenuity is it likely to possess.

" But some may ask (continues Helvetius), why monkeys, whose paws are nearly as dexterous as our hands, do not make a progress equal to that of man? A variety of causes (he observes) conspire to fix them in that state of inferiority in which we find them:—1. Men are more multiplied upon the earth. 2. Among the different species of monkeys, there are few whose strength can be compared with that of man; and, accordingly, they form only a fugitive society before the human race. 3. Monkeys being frugiverous, have fewer wants, and, therefore, less invention than man. 4. Their life is shorter. And, finally, the organical structure of their bodies keeping them, like children, in perpetual motion, even after their desires are satisfied, they are not susceptible of lassitude *(ennui)*, which ought to be considered (as I shall prove afterwards) as one of the principles to which the human mind owes its improvement.

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[1] In combating the philosophy of Helvetius, La Harpe (whose philosophical opinions seem, on many occasions, to have been not a little influenced by his private partialities and dislikes) exclaims loudly against the same principles to which he had tacitly given his unqualified approbation in speaking of Condillac. On this occasion he is at pains to distinguish between the doctrines of the two writers; asserting that Condillac considered our senses as only the *occasional* causes of our ideas, while Helvetius represented the former as the *productive* causes of the latter.—*(Cours de Litterat.* Tome XV. pp. 348, 349.) But that this is by no means reconcileable with the general spirit of Condillac's works (although perhaps some detached expressions may be selected from them admitting of such an interpretation), appears sufficiently from the passages formerly quoted. In addition to these, I beg leave to transcribe the following: " Dans le système que toutes nos connoisances viennent des sens, rien n'est plus aisé que de se faire une notion exacte des idées. Car elles ne sont que des sensations ou des portions extraites de quelque sensation pour être considerées à part; ce qui produit deux sortes d'idées, les sensibles et les abstraites."—*(Traité des Systèmes*, Chap. vi.) " Puisque nous avons vu que le souvenir n'est qu'une manière de sentir, c'est une consequence, que les idées intellectuelles ne différent pas essentiellement des sensations mêmes."—*(Traité des Sensations*, Chap. viii. § 33.) Is not this precisely the doctrine and even the language of Helvetius?

In the same passage of the *Lycée*, from which the above quotation is taken from La Harpe, there is a sweeping judgment pronounced on the merits of Locke, which may serve as a specimen of the author's competency to decide on metaphysical questions: " Locke a prouvé autant qu'il est possible à l'homme, que l'âme est une substance simple et indivisible, et par conséquent immaterielle. Cependant, il ajoute, qu'il n'oseroit affirmer que Dieu ne puisse douer la matière de pensée. Condillac est de son avis sur le premier article, et le combat sur le second. Je suis entièrement de l'avis de Condillac, et *tous les bons métaphysiciens conviennent que c'est la seule inexactitude qu'on puisse relever dans l'ouvrage de Locke.*"—*(Cours de Litterat.* Tome XV. p. 149.)

"By combining (he adds) all these differences between the nature of man and of beast, we may understand why sensibility and memory, though faculties common to man and to the lower animals, are in the latter only sterile qualities."[1]

The foregoing passage is translated literally from a note on one of the first paragraphs of the book *De l'Esprit;* and in the sentence of the text to which the note refers, the author triumphantly asks, "Who can doubt, that if the wrist of a man had been terminated by the hoof of a horse, the species would still have been wandering in the forest?"

Without attempting any examination of this shallow and miserable theory, I shall content myself with observing, that it is not peculiar to the philosophers of modern France. From the *Memorabilia* of Xenophon it appears, that it was current among the sophists of Greece; and the answer given it by Socrates is as philosophical and satisfactory as any thing that could possibly be advanced in the present state of the sciences.

"And canst thou doubt, Aristodemus, if the gods take care of man? Hath not the privilege of an erect form been bestowed on him alone? Other animals they have provided with feet, by which they may be removed from one place to another; but to man they have also given the use of the hand. A tongue hath been bestowed on every other animal; but what animal, except man, hath the power of making his thoughts intelligible to others?

"Nor is it with respect to the body alone that the gods have shown themselves bountiful to man. Who seeth not that he is as it were a god in the midst of this visible creation? So far doth he surpass all animals whatever in the endowments of his body and his mind. For if the body of the ox had been joined to the mind of man, the invention of the latter would have been of little avail, while unable to execute his purposes with facility. Nor would the human form have been of more use to the brute, so long as he remained destitute of understanding. But in thee, Aristodemus, hath been joined to a wonderful soul, a body no less wonderful; and sayst thou, after this, the gods take no care of me? What wouldst thou then more to convince thee of their care?"[2]

A very remarkable passage to the same purpose occurs in Galen's treatise, *De Usu Partium.* "But as of all animals man is the wisest, so *hands* are well fitted for the purposes of a wise animal. For it is not because he had hands that he is therefore wiser than the rest, as Anaxagoras alleged; but because he was wiser than the rest that he had therefore hands, as Aristotle has most wisely judged. Neither was it his hands, but his reason, which instructed man in the arts. The hands are only the organs by which the arts are practised."[3]

The contrast, in point of elevation, between the tone of French philosophy, and that of the best heathen moralists, was long ago remarked by Addison; and of this contrast it would be difficult to find a better illustration than the passages which have just been quoted.

The disposition of ingenious men to pass suddenly from one extreme to another in matters of controversy, has, in no instance, been more strikingly exemplified than in the opposite theories concerning the nature of the brutes, which successively became fashionable in France during the last century. While the prevailing creed of French materialists leads to the rejection of every theory which professes to discriminate the rational mind from the animal principle of action, it is well known that, but a few years before, the disciples of Descartes allowed no one faculty to belong to man and brutes in common; and even went so far as to consider the latter in the light of mere machines. To this paradox the author was probably led, partly by his anxiety to elude the objection which the faculties of the lower animals have been supposed to present to the doctrine of the immortality of the soul, and partly by the difficulty of reconciling their sufferings with the Divine Goodness.

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[1] It is not a little surprising that, in the above enumeration, Helvetius takes no notice of the want of *language* in the lower animals; a faculty without which, the multiplication of individuals could contribute nothing to the improvement of the species. Nor is this want of language in the brutes owing to any defect in the organs of speech; as sufficiently appears from those tribes which are possessed of the power of articulation in no inconsiderable degree. It plainly indicates, therefore, some defect in those higher principles which are connected with the use of artificial signs.

[2] Mrs Sarah Fielding's Translation.

[3] GALEN, *De Us. Part.* l. l. c. 3.

Absurd as this idea may now appear, none of the tenets of Descartes were once adopted with more implicit faith by some of the profoundest thinkers in Europe. The great Pascal admired it as the finest and most valuable article of the Cartesian system; and of the deep impression it made on the mind of Malebranche, a most decisive proof was exhibited by himself in the presence of Fontenelle. "M. de Fontenelle contoit," says one of his intimate friends,[1] "qu'un jour étant allé voir Malebranche aux PP. de l'Oratoire de la Rue St Honoré, une grosse chienne de la maison, et qui étoit pleine, entra dans la salle où ils se promenoient, vint caresser le P. Malebranche, et se rouler à ses pieds. Aprés quelques mouvemens inutiles pour la chasser, le philosophe lui donna un grand coup de pied, qui fit jetter à la chienne un cri de douleur, et à M. de Fontenelle un cri de compassion. Eh quoi (lui dit froidement le P. Malebranche) ne sçavez vous pas bien que cela ne se sent point?"

On this point Fontenelle, though a zealous Cartesian, had the good sense to dissent openly from his master, and even to express his approbation of the sarcastic remark of La Motte, *que cette opinion sur les animaux étoit une débauche de raisonnement.* Is not the same expression equally applicable to the opposite theory quoted from Helvetius?[2]

From those representations of human nature which tend to assimilate to each other the faculties of man and of the brutes, the transition to atheism is not very wide. In the present instance, both conclusions seem to be the necessary corollaries of the same fundamental maxim. For if all the sources of our knowledge are to be found in the external senses, how is it possible for the human mind to rise to a conception of the Supreme Being, or to that of any other truth either of natural or of revealed religion?

To this question Gassendi and Condillac, it cannot be doubted, were both able to return an answer, which seemed to themselves abundantly satisfactory. But how few of the multitude are competent to enter into these refined explanations? And how much is it to be dreaded, that the majority will embrace, with the general principle, all the more obvious consequences which to their own gross conceptions it seems necessarily to involve? Something of the same sort may be remarked in the controversy about the freedom of the human will. Among the multitudes whom Leibnitz and Edwards have made converts to the scheme of necessity, how comparatively inconsiderable is the number who have acquiesced in their subtle and ingenious attempts to reconcile this scheme with man's accountableness and moral agency?

Of the prevalence of atheism at Paris, among the higher classes, at the period of which we are now speaking, the *Memoires* and *Correspondance* of the Baron de Grimm afford the most unquestionable proofs.[3] His friend Diderot seems to have been one of its most zealous abettors; who,

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[1] The Abbé Trublet in the *Mercure de Juillet*, 1757.—(See *Œuvres de Fontenelle*, Tome II. p. 137. Amsterdam, 1764.)

[2] In La Fontaine's *Discours à Madame de la Sablière* (Liv. X. Fable I.), the good sense with which he points out the extravagance of both these extremes is truly admirable. His argument (in spite of the fetters of rhyme) is stated, not only with his usual grace, but with singular clearness and precision; and considering the period when he wrote, reflects much honour on his philosophical sagacity.

[3] The *Système de la Nature* (the boldest, if not the ablest, publication of the Parisian atheists) appeared in 1770. It bore on the title-page the name of Mirabaud, a respectable but not very eminent writer, who, after long filling the office of perpetual secretary to the French Academy, died at a very advanced age in 1760. (He was chiefly known as the author of very indifferent translations of *Tasso* and *Ariosto.)* It is now, however, universally admitted that Mirabaud had no share whatever in the composition of the *Système de la Nature.* It has been ascribed to various authors; nor am I quite certain, that, among those who are most competent to form a judgment upon this point, there is yet a perfect unanimity. In one of the latest works which has reached this country from France (the *Correspondance inédite de Galiani*, 1818), it seems to be assumed by the editors, as an acknowledged fact, that it proceeded from the pen of the Baron d'Holbach. The Abbé Galiani having remarked, in one of his letters to Madame Epinay, that it appeared to him to come from the same hand with the *Christianisme Devoilé* and the *Militaire Philosophe*, the editors remark in a note, "On peut rendre homage à la sagacité de l'Abbé Galiani. *Le Christianisme Devoilé* est en effet le premier ouvrage philosophique du Baron d'Holbach. C'est en vain que la *Biographie Universelle* nous assure, d'après le temoignage de Voltaire, que cet ouvrage est de Damilaville."

Having mentioned the name of Damilaville, I am tempted to add, that the article relating to him in the *Biographie Universelle*, notwithstanding the incorrectness with which it is charged in the foregoing passage, is not unworthy of the reader's it appears from various accounts, contributed to render it fashionable, still more by the extraordinary powers of his conversation, than by the odd combination of eloquence and of obscurity displayed in all his metaphysical productions.[1]

In order, however, to prevent misapprehension of my meaning, it is proper for me to caution my readers against supposing that *all* the eminent French philosophers of this period were of the same school with Grimm and Diderot. On this subject many of our English writers have been misled by taking for granted that to speak lightly of final causes is, of itself, sufficient proof of atheism. That this is a very rash as well as uncharitable conclusion, no other proof is necessary than the manner in which final causes are spoken of by Descartes himself, the great object of whose metaphysical writings plainly was, to establish by demonstration the existence of God. The following vindication of this part of the Cartesian philosophy has been lately offered by a French divine, and it may be extended with equal justice to Buffon and many others of Descartes's successors: " Quelques auteurs, et particulièrement Leibnitz, ont critiqué cette partie de la doctrine de Descartes; mais nous la croyons irreprochable, si on veut bien l'entendre, et remarquer que Descartes ne parle que des *Fins totales* de Dieu. Sans doute, le soleil par exemple, et les étoiles, ont été faits pour l'homme, dans ce sens, que Dieu, en les créant, a eu en vue l'utilité de l'homme; et cette utilité a été sa fin. Mais cette utilité a-t-elle été l'unique fin de Dieu? Croit-on qu'en lui attribuant d'autres fins, on affoibliroit la reconnoissance de l'homme, et l'obligation où il est de louer et de benir Dieu dans toutes ses œuvres? Les auteurs de la vie spirituelle, les plus mystiques même, et les plus accrédités, ne l'ont pas cru."—(M. l'Abbé Emery, *Editor of the Thoughts of Descartes upon Religion and Morals*, Paris, 1811, p. 79.)

As to the unqualified charge of atheism, which has been brought by some French ecclesiastics against all of their countrymen that have presumed to differ from the tenets of the Catholic church, it will be admitted, with large allowances, by every candid Presbyterian, when it is recollected that something of the same illiberality formerly existed under the comparatively enlightened establishment of England. In the present times, the following anecdote would appear incredible, if it did not rest on the unquestionable testimony of Dr Jortin: " I heard Dr B. say in a sermon, if any one denies the uninterrupted succession of bishops, I shall not scruple to call him a downright atheist. This, when I was young (Jortin adds), was sound, orthodox, and fashionable doctrine."—(*Tracts*, Vol. I. p. 436.)[2]

How far the effects of that false philosophy of which Grimm's correspondence exhibits so dark and so authentic a picture, were connected with the awful revolution which soon after followed, it is not easy to say. That they contributed greatly to blacken its atrocities, as well as to revolt against it the feelings of the whole Christian world, cannot be disputed. The experiment was indeed tremendous, to set loose the passions of all classes of men from the restraints

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attention, as it contains some very remarkable marginal notes on the *Christianisme Devoilé*, copied from Voltaire's own handwriting.

Since writing the above note, I have seen the Memoirs of M. Suard, by M. Garat (Paris, 1820), in which the biographer, whose authority on this point is perfectly decisive, ascribes with confidence to Baron d'Holbach the *Système de la Nature*, and also a work entitled *La Morale et La Legislation Universelle* (Vol. I. pp. 210, 211.)

According to the same author, the Baron d'Holbach was one of Diderot's proselytes.—(*Ibid.* p. 208.) His former creed, it would appear, had been very different.

[1] And yet Diderot, in some of his lucid intervals, seems to have thought and felt very differently. See Note TT.

[2] See Note U U.

Of the levity and extravagance with which such charges have sometimes been brought forward, we have a remarkable instance in a tract entitled *Athei Detecti*, by a very learned Jesuit *Father Hardouin;* (see his *Opera Varia Posthuma*, Amsterdam, 1733, in fol.) where, among a number of other names, are to be found those of Jansenius, Descartes, Malebranche, Arnauld, Nicole, and Pascal. Large additions on grounds equally frivolous, have been made in later times, to this list, by authors, who having themselves made profession of Atheism, were anxious, out of vanity, to swell the number of their sect. Of this kind was a book published at Paris, under some of the revolutionary governments, by *Pierre Sylvain Marechal*, entitled *Dictionnaire des Athées*. Here we meet with the names of St Chrysostom, St Augustin, Pascal, Bossuet, Fenelon, Bellarmin, Labruyere, Leibnitz, and many others not less unexpected. This book he is said to have published at the suggestion of the celebrated astronomer Lalande, who afterwards published a supplement to the Dictionary, supplying the omissions of the author. See the *Biographie Universelle*, articles *Marechal, Lalande.*

imposed by religious principles; and the result exceeded, if possible, what could have been anticipated in theory. The lesson it has afforded has been dearly purchased; but let us indulge the hope that it will not be thrown away on the generations which are to come.

A prediction, which Bishop Butler hazarded many years before, does honour to his political sagacity, as well as to his knowledge of human nature; that the spirit of irreligion would produce, some time or other, political disorders, similar to those which arose from religious fanaticism in the seventeenth century.[1]

Nearly about the time that the *Encyclopédie* was undertaken, another set of philosophers, since known by the name of *Economists*, formed themselves into an association for the purpose of enlightening the public on questions of political economy. The object of their studies seemed widely removed from all abstract discussion; but they had, nevertheless, a metaphysical system of their own, which, if it had been brought forward with less enthusiasm and exaggeration, might have been useful in counteracting the gloomy ideas then so generally prevalent about the order of the universe. The whole of their theory proceeds on the supposition that the arrangements of nature are wise and benevolent, and that it is the business of the legislator to study and co-operate with her plans in all his own regulations. With this principle, another was combined, that of the indefinite improvement of which the human mind and character are susceptible; an improvement which was represented as a natural and necessary consequence of wise laws, and which was pointed out to legislators as the most important advantage to be gained from their institutions.

These speculations, whatever opinion may be formed of their solidity, are certainly as remote as possible from any tendency to atheism, and still less do they partake of the spirit of that philosophy which would level man with the brute creation. With their practical tendency in a *political* view we are not at present concerned; but it would be an unpardonable omission, after what has been just said of the metaphysical theories of the same period, not to mention the abstract principles involved in the Economical System, as a remarkable exception to the general observation. It may be questioned, too, if the authors of this system, by incorporating their ethical views with their political disquisitions, did not take a more effectual step towards discountenancing the opinions to which they were opposed, than if they had attacked them in the way of direct argument.[2]

On the metaphysical theories which issued from the French press during the latter half of the last century, I do not think it necessary for me to enlarge, after what I have so fully stated in some of my former publications. To enter into details with respect to particular works would be superfluous, as the remarks made upon any one of them are nearly applicable to them all. The excellent writings of M. Prevost, and of M. Degerando, will, it is to be hoped, gradually introduce into France a sounder taste in this branch of philosophy.[3] At present, so far as I am acquainted with the state of what is called

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[1] "Is there no danger that all this may raise somewhat like that levelling spirit, upon atheistical principles, which, in the last age, prevailed upon enthusiastic ones? Not to speak of the possibility, that different sorts of people may unite in it upon these contrary principles."—(*Sermon preached before the House of Lords*, January 30, 1741.)

As the fatal effects of both these extremes have, in the course of the two last centuries, been exemplified on so gigantic a scale in the two most civilised countries of Europe, it is to be hoped that mankind may in future derive some salutary admonitions from the experience of their predecessors. In the meantime, from that disposition common both to the higher and lower orders to pass suddenly from one extreme to another, it is at least possible that the strong re-action produced by the spirit of impiety during the French Revolution may, in the first instance, impel the multitude to something approaching to the puritanical fanaticism and frenzy of the Cromwellian Commonwealth.

[2] For some other observations on the Ethical principles assumed in the Economical System, see *Elements of the Philosophy of the Human Mind*, Vol. II. Chap. iv. Sect. 6. § 1. towards the end.

[3] Some symptoms of such a reformation are admitted already to exist, by an author decidedly hostile to all philosophical systems. "Bacon, Locke, Condillac, cherchoient dans nos sens l'origine de nos idées; Helvetius y a trouvé nos idées elles-mêmes. *Juger*, selon ce philosophe, *n'est autre chose que sentir.** Aujourd'hui les bons esprits, éclairés par les événemens

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* I was somewhat surprised, in looking over very lately the *Principia* of Descartes, to find (what had formerly escaped me), that the mode of speaking objected to in the above paragraph may plead in its favour the authority of that philosopher: "Cogitationis nomine, intelligo illa omnia, quæ nobis consciis in nobis fiunt, quatenus eorum in nobis conscientia est: Atque

Idéologie in that country, it does not appear to me to furnish much matter either for the instruction or amusement of my readers.

The works of Rousseau have, in general, too slight a connection with metaphysical science, to come under review in this part of my discourse. But to his *Emile*, which has been regarded as a supplement to Locke's *Treatise on Education*, some attention is justly due, on account of various original and sound suggestions on the management of the infant mind, which, among many extravagancies, savouring strongly both of intellectual and moral insanity, may be gathered by a sober and discriminating inquirer. The estimate of the merits of this work, formed by Mr Gray, appears to me so just and impartial, that I shall adopt it here without a comment.

"I doubt" (says he, in a letter to a friend) "you have not yet read Rousseau's *Emile*. Every body that has children should read it more than once; for though it abounds with his usual glorious absurdity, though his general scheme of education be an impracticable chimera, yet there are a thousand lights struck out, a thousand important truths better expressed than ever they were before, that may be of service to the wisest men. Particularly, I think he has observed children with more attention, knows their meaning, and the working of their little passions, better than any other writer. As to his religious discussions, which have alarmed the world, and engaged their thoughts more than any other parts of his book, I set them all at nought, and wish they had been omitted."—(GRAY'S *Works by Mason*, Letter 49.)

The most valuable additions made by French writers to the Philosophy of the Human Mind are to be found, not in their systematical treatises on metaphysics, but in those more popular compositions, which, professing to paint the prevailing manners of the times, touch occasionally on the varieties of intellectual character. In this most interesting and important study, which has been hitherto almost entirely neglected in Great Britain,[1] France must be allowed not only to have led the way, but to remain still unrivalled. It would be endless to enumerate names; but I must not pass over those of Vauvenargues[2] and Du-

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sur la secrete tendance de toutes ces opinions, les ont soumises à un examen plus sevère. La *transformation* des sensations en idées ne paroit plus qu'un mot vide de sens. On trouve que *l'homme statue* ressemble un peu trop à *l'homme machine*, et Condillac est modifié ou même combattu sur quelques points, par tous ceux qui s'en servent encore dans l'enseignement philosophique."—(*Recherches Philosophiques, &c.* par M. DE BONALD, Tome I. pp. 34. 35.)

[1] Many precious hints connected with it may, however, be collected from the writings of Lord Bacon, and a few from those of Mr Locke. It does not seem to have engaged the curiosity of Mr Hume in so great a degree as might have been expected from his habits of observation and extensive intercourse with the world. The objects of Dr Reid's inquiries led him into a totally different track.

Among German writers, Leibnitz has occasionally glanced with a penetrating eye at the varieties of genius; and it were to be wished that he had done so more frequently. How far his example has been followed by his countrymen in later times, I am unable to judge, from my ignorance of their language.

A work expressly on this subject was published by a Spanish physician (Huarte) in the seventeenth century. A French translation of it, printed at Amsterdam in 1672, is now lying before me. It is entitled, *Examen des Esprits pour les Sciences. Où se montrent les differences des Esprits, qui se trouvent parmi les hommes, et à quel genre de Science chacun est propre en particulier.* The execution of this work certainly falls far short of the expectations raised by the title; but, allowances being made for the period when it was written, it is by no means destitute of merit, nor unworthy of the attention of those who may speculate on the subject of Education. For some particulars about its contents, and also about the author, see Bayle's *Dictionary*, Art. *Huarte*; and *The Spectator*, No. 30.

[2] The Marquis de Vauvenargues, author of a small volume, entitled *Introduction à la Connoissance de l'Esprit Humain.* He entered into the army at the age of eighteen, and continued to serve for nine years; when, having lost his health irrecoverably, in consequence of the fatigues he underwent in the memorable retreat from Prague, in December 1742, he resolved to quit his profession, in the hope of obtaining some diplomatic employment better suited to his broken constitution. Soon after, he was attacked by the small-pox, which unfortunately turned out of so malignant a kind, as to disfigure his countenance, and deprive him almost totally of sight. He died in 1747, at the age of thirty-two. The small volume above mentioned was published the year before his death. It bears everywhere the marks of a powerful, original, and elevated mind; and the imperfect education which the author appears to have received gives it an additional charm, as the genuine result of his own unsophisticated reflections.

Marmontel has given a most interesting picture of his social character: "En le lisant, je crois encore l'entendre, et je ne

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ita non modo intelligere, velle, imaginari, sed etiam sentire, idem est hic quod cogitare."—(*Princ. Phil.* p. 2.) Dr Reid, too, has said that "the sensation of colour is a sort of thought" (*Inquiry*, Chap. vi. § 4.); but no names, how great soever, can sanction so gross an abuse of language.

After all, there is some difference between saying, that sensation is a sort of thought, and that thought is a sort of sensation.

clos.[1] Nor can I forbear to remark, in justice to an author whom I have already very freely censured, that a variety of acute and refined observations on the different modifications of genius may be collected from the writings of Helvetius. The soundness of some of his distinctions may perhaps be questioned; but even his attempts at classification may serve as useful guides to future observers, and may supply them with a convenient nomenclature, to which it is not always easy to find corresponding terms in other languages. As examples of this, it is sufficient to mention the following phrases: *Esprit juste, Esprit borné, Esprit étendu, Esprit fin, Esprit délié, Esprit de lumière.* The peculiar richness of the French tongue in such appropriate expressions (a circumstance, by the way, which not unfrequently leads foreigners to overrate the depth of a talkative Frenchman) is itself a proof of the degree of attention which the ideas they are meant to convey have attracted in that country among the higher and more cultivated classes.

The influence, however, of the philosophical spirit on the general habits of thinking among men of letters in France, was in no instance displayed to greater advantage, than in the numerous examples of *theoretical* or *conjectural* history, which appeared about the middle of last century. I have already mentioned the attempts of Condillac and others, to trace upon this plan the first steps of the human mind in the invention of language. The same sort of speculation has been applied with greater success to the mechanical and other necessary arts of civilised life;[2] and still more ingeniously and happily to the different branches of pure and mixed mathematics. To a philosophical mind, no study certainly can be more delightful than this species of history; but as an organ of instruction, I am not disposed to estimate its practical utility so highly as D'Alembert. It does not seem to me at all adapted to interest the curiosity of novices: nor is it so well calculated to engage the attention of those who wish to enlarge their scientific knowledge, as of persons accustomed to reflect on the phenomena and laws of the intellectual world.

Of the application of theoretical history, to account for the diversities of laws and modes of government among men, I shall have occasion afterwards to speak. At present I shall only remark the common relation in which all such researches stand to the Philosophy of the Human Mind, and their common tendency to expand and to liberalise the views of those who are occupied in the more confined pursuits of the subordinate sciences.

After what has been already said of the general tone of French philosophy, it will not appear surprising, that a system so mystical and spiritual as that of Leibnitz never struck its roots deeply in that country. A masterly outline of its principles was published by Madame du Chatelet, at a period of her life when she was an enthusiastic admirer of the author; and a work on such a subject, composed by a lady of her rank and genius, could not fail to produce at first a very strong sensation at Paris; but not long after, she herself abandoned the

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sais si sa conversation n'avait pas même quelque chose de plus animé, de plus délicat que ses divins ecrits." And, on a different occasion, he speaks of him thus: "Doux, sensible, compatissant, il tenait nos âmes dans ses mains. Une sérénité inaltérable dérobait ses douleurs aux yeux de l'amitié. Pour soutenir l'adversité, on n'avoit besoin que de son exemple; et témoin de l'égalité de son âme, on n'osait être malheureux avec lui." See also an eloquent and pathetic tribute to the genius and worth of Vauvenargues, in Voltaire's *Eloge Funèbre des Officiers qui sont morts dans la Guerre de* 1741.

If the space allotted to him in this note should be thought to exceed what is due to his literary eminence, the singular circumstances of his short and unfortunate life, and the deep impression which his virtues, as well as his talents, appear to have left on the minds of all who knew him, will, I trust, be a sufficient apology for my wish to add something to the celebrity of a name, hitherto, I believe, very little known in this country.

[1] The work of Duclos, here referred to, has for its title, *Considérations sur les Mœurs de ce Siècle.* Gibbon's opinion of this book is, I think, not beyond its merits: "L'ouvrage en général est bon. Quelques chapitres (le rapport de l'esprit et du caractère) me paroissent excellens."—*(Extrait du Journal.)*

I have said nothing of La Rochefoucauld and La Bruyère, as their attention was chiefly confined to manners, and to moral qualities. Yet many of their remarks show, that they had not wholly overlooked the diversities among men in point of intellect. An observer of sagacity equal to their's might, I should think, find a rich field of study in this part of human nature, as well as in the other.

[2] Particularly by the President de Goguet, in his learned work, entitled, "*De l'Origine des Lois, des Arts, et des Sciences, et de leurs Progrès chez les Anciens Peuples.*" Paris, 1758.

German philosophy, and became a zealous partizan of the Newtonian school. She even translated into French, and enriched with a commentary, the *Principia* of Newton ; and by thus renouncing her first faith, contributed more to discredit it, than she had previously done to bring it into fashion. Since that time, Leibnitz has had few, if any, disciples in France, although some of his peculiar tenets have occasionally found advocates there, among those who have rejected the great and leading doctrines, by which his system is more peculiarly characterised. His opinions and reasonings in particular, on the necessary concatenation of all events, both physical and moral (which accorded but too well with the philosophy professed by Grimm and Diderot), have been long incorporated with the doctrines of the French materialists, and they have been lately adopted and sanctioned, in all their extent, by an author, the unrivalled splendour of whose mathematical genius may be justly suspected, in the case of some of his admirers, to throw a false lustre on the dark shades of his philosophical creed.[1]

Notwithstanding, however, this important and unfortunate coincidence, no two systems can well be imagined more strongly contrasted on the whole, than the lofty metaphysics of Leibnitz, and that degrading theory concerning the origin of our ideas, which has been fashionable in France since the time of Condillac. In proof of this, I have only to refer to the account of both, which has been already given.

The same contrast, it would appear, still continues to exist between the favourite doctrines of the German and of the French schools. "In the French empiricism (says a most impartial, as well as competent judge, M. Ancillon), the faculty of feeling, and the faculty of knowing,

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[1] "Les événemens actuels ont avec les précédens une liaison fondée sur le principe évident, qu'une chose ne peut pas commencer d'être, sans une cause qui la produise. Cet axiome, connu sous le nom de *principe de la raison suffisante*, s'étend aux actions même que l'on juge indifférentes. La volonté la plus libre ne peut, sans un motif déterminant, leur donner naissance ; car si, toutes les circonstances de deux positions étant exactement semblables, elle agissoit dans l'une et s'abstenoit d'agir dans l'autre, son choix seroit un effet sans cause ;[*] elle seroit alors, dit Leibnitz, le *hazard aveugle* des Epicuriens. L'opinion contraire est une illusion de l'esprit qui perdant de vue les raisons fugitives du choix de la volonté dans les choses indifférentes, se persuade qu'elle s'est déterminée d'elle même et sans motifs.

"Nous devons donc envisager l'état présent de l'univers comme l'effet de son état antérieure, et comme la cause de celui qui va suivre. Une intelligence qui pour un instant donné connoitroit toutes les forces dont la nature est animée, et la situation respective des êtres qui la composent, si d'ailleurs elle étoit assez vaste pour soumettre ces données à l'analyse, embrasseroit dans la même formule, les mouvemens des plus grands corps de l'univers et ceux de plus léger atôme. Rien ne seroit incertain pour elle, et l'avenir comme le passé, seroit présent à ses yeux."—(*Essai Philosophique sur les Probabilités*, par LAPLACE.)

Is not this the very spirit of the *Theodicœa* of Leibnitz, and, when combined with the other reasonings in the *Essay on Probabilities*, the very essence of Spinozism ?

This, indeed, is studiously kept by the author out of the reader's view ; and hence the facility with which some of his propositions have been admitted by many of his *mathematical* disciples, who, it is highly probable, were not aware of the consequences which they necessarily involve.

I cannot conclude this note without recurring to an observation ascribed in the above quotation from Laplace to Leibnitz, " that the *blind chance* of the Epicureans involves the supposition of an effect taking place without a cause." This, I apprehend, is a very incorrect statement of the philosophy taught by Lucretius, which nowhere gives the slightest countenance to such a supposition. The distinguishing tenet of this sect was, that the order of the universe does not imply the existence of *intelligent* causes, but may be accounted for by the active powers belonging to the atoms of matter ; which active powers, being exerted through an indefinitely long period of time, *might* produce, nay, *must* have produced, exactly such a combination of things, as that with which we are surrounded. This, it is evident, does not call in question the necessity of a cause to produce every effect, but, on the contrary, virtually assumes the truth of that axiom. It only excludes from these causes the attribute of intelligence. It is in the same way when I apply the words blind chance (*hazard aveugle*) to the throw of a die, I do not mean to deny that I am ultimately the cause of the particular event that is to take place ; but only to intimate that I do not here act as a *designing* cause, in consequence of my ignorance of the various accidents to which the die is subjected, while shaken in the box. If I am not mistaken, this *Epicurean Theory* approaches very nearly to the scheme, which it is the main object of the *Essay on Probabilities* to inculcate ; and, therefore, it was not quite fair in Laplace to object to the supposition of man's free agency, as favouring those principles which he himself was labouring indirectly to insinuate.

From a passage in Plato's *Sophist*, it is very justly inferred by Mr Gray, that, according to the *common* opinion then entertained, " the creation of things was the work of blind unintelligent matter ; whereas the contrary was the result of philosophical reflection and disquisition believed by a few people only."—(*Gray's Works* by MATTHIAS, Vol. II. p. 414.) On the same subject, see SMITH'S *Posthumous Essays*, p. 106.

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[*] The impropriety of this language was long ago pointed out by Mr Hume. " They are still more frivolous who say, that every effect must have a cause, because it is implied in the very idea of effect. Every effect necessarily presupposes a cause ; effect being a relative term, of which cause is the co-relative. The true state of the question is, whether every object, which begins to exist, must owe its existence to a cause ?"—(*Treatise of Human Nature*, Vol. I. p. 147.)

are one and the same. In the new philosophy of Germany, there is no faculty of knowing, but reason. In the former, taking our departure from individuals, we rise by degrees to ideas, to general notions, to principles. In the latter, beginning with what is most general, or rather with what is universal, we descend to individual existences, and to particular cases. In the one, what we see, what we touch, what we feel, are the only realities. In the other, nothing is real but what is invisible and purely intellectual."

" Both these systems (continues M. Ancillon) result from the exaggeration of a sound principle. They are both true and both false in part; true in what they admit, false in what they reject. All our knowledge begins, or appears to begin, in sensation; but it does not follow from this that it is all derived from sensation, or that sensation constitutes its whole amount. The proper and innate activity of the mind has a large share in the origin of our *representations*, our sentiments, our ideas. Reason involves principles which she does not borrow from without, which she owes only to herself, which the impressions of the senses call forth from their obscurity, but which, far from owing their origin to sensations, serve to appreciate them, to judge of them, to employ them as instruments. It would be rash, however, to conclude from hence, that there is no certainty but in reason, that reason alone can seize the mystery of existences, and the intimate nature of beings, and that experience is nothing but a vain appearance, destitute of every species of reality."[1]

With this short and comprehensive estimate of the new German philosophy, pronounced by one of the most distinguished members of the Berlin Academy, I might perhaps be pardoned for dismissing a subject, with which I have, in some of my former publications, acknowledged myself (from my total ignorance of the German language) to be very imperfectly acquainted; but the impression which it produced for a few years in England (more particularly while our intercourse with the Continent was interrupted), makes it proper for me to bestow on it a little more notice in this Dissertation, than I should otherwise have judged necessary or useful.

SECTION VII.

Kant and other Metaphysicians of the New German School.[2]

THE long reign of the Leibnitzian Philosophy in Germany was owing, in no inconsiderable degree, to the zeal and ability with which it was taught in that part of Europe, for nearly half a century, by his disciple Wolfius,[1] a man of little genius, originality, or taste, but whose extensive and various learning, seconded by a methodical head,[2] and by an incredible industry and perseverance, seems to have been peculiarly fitted to command the admiration of his countrymen. Wolfius, indeed, did not profess to follow implicitly the opinions of his master, and, on some points, laid claim to peculiar ideas of his own; but the spirit of his philosophy is essentially the same with that of Leibnitz,[3] and the particulars in which he dissented from him are too trifling to deserve any notice in the history of literature.[4]

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[1] *Mélanges de Litterature et de Philosophie*, par F. ANCILLON, Préface. (à Paris, 1809.) The intimacy of M. Ancillon's literary connections both with France and with Germany entitle his opinions on the respective merits of their philosophical systems to peculiar weight. If he anywhere discovers a partiality for either, the modest account which he gives of himself would lead us to expect his leaning to be in favour of his countrymen. " Placé entre la France et l'Allemagne, appartenant à la première par la langue dans laquelle je hasarde d'écrire, à la seconde par ma naissance, mes études, mes principes, mes affections, et j'ose le dire, par la couleur de ma pensée, je desirerois pouvoir servir de mediateur littéraire, ou d'interprète philosophique entre les deux nations."

In translating from M. Ancillon the passage quoted in the text, I have adhered as closely as possible to the words of the original; although I cannot help imagining that I could have rendered it still more intelligible to the English reader by laying aside some of the peculiarities of his German phraseology. My chief reason for retaining these, was to add weight to the strictures which a critic, so deeply tinctured with the German habits of thinking and of writing, has offered, on the most prominent faults of the systems in which he had been educated.

[2] My ignorance of German would have prevented me from saying anything of the philosophy of Kant, if the extraordinary pretensions with which it was at first brought forward in this island, contrasted with the total oblivion into which it soon after very suddenly fell, had not seemed to demand some attention to so wonderful a phenomenon in the literary history of the eighteenth century. My readers will perceive that I have taken some pains to atone for my inability to read Kant's works in the original, not only by availing myself of the Latin version of Born, but by consulting various comments on them which have appeared in the English, French, and Latin languages. As commentators, however, and even translators, are not always to be trusted to as unexceptionable interpreters of their authors' opinions, my chief reliance has been placed on one of Kant's own compositions in Latin; his Dissertation *De Mundi Sensibilis atque Intelligibilis Forma et Principiis*, which he printed as the subject of a public disputation, when he was candidate for a Professorship in the Uni-

The high reputation so long maintained by Wolfius in Germany suggested, at different times, to the book-makers at Paris, the idea of introducing into France the philosophy which he taught. Hence a number of French abridgments of his logical and metaphysical writings. But an attempt, which had failed in the hands of Madame de Chatelet, was not likely to succeed with the admirers and abridgers of Wolfius.[5]

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versity of Kœnigsberg. It is far from being improbable, after all, that I may, in some instances, have misapprehended his meaning, but I hope I shall not be accused of wilfully misrepresenting it. Where my remarks are borrowed from other writers, I have been careful in referring to my authorities, that my reader may judge for himself of the fidelity of my statements. If no other purpose, therefore, should be answered by this part of my work, it may at least be of use by calling forth some person properly qualified to correct any mistakes into which I may involuntarily have fallen; and, in the meantime, may serve to direct those who are strangers to German literature, to some of the comments on this philosophy which have appeared in languages more generally understood in this country.

[1] Born 1679. Died 1754.

[2] The display of method, however, so conspicuous in all the works of Wolfius, will often be found to amount to little more than an aukward affectation of the phraseology and forms of mathematics, in sciences where they contribute nothing to the clearness of our ideas, or the correctness of our reasonings. This affectation, which seems to have been well adapted to the taste of Germany at the time when he wrote, is now one of the chief causes of the neglect into which his writings have fallen. Some of them may still be usefully consulted as dictionaries, but to read them is impossible. They amount to about forty quarto volumes, twenty-three of which are in Latin, the rest in German.

In his own country the reputation of Wolfius is not yet at an end. In the preface to Kant's *Critique of Pure Reason*, he is called " Summus omnium dogmaticorum Philosophus."—(KANTII *Opera ad Philosophiam Criticam*, Vol. I. Præf. Auctoris Posterior, p. xxxvi. Latine Vertit. Fred. Born. Lipsiæ, 1796.) And by one of Kant's best commentators his name is advantageously contrasted with that of David Hume: " Est autem scientifica methodus aut dogmatica, aut sceptica. Primi generis autorem celeberrimum Wolfium, alterius Davidem Humium nominasse sat est." (*Expositio Philos. Criticæ.* Autore Conrado Friderico a Schmidt-Phiseldek. Hafniæ, 1796.)

To the other merits of Wolfius it may be added, that he was one of the first who contributed to diffuse among his countrymen a taste for philosophical inquiries, by writing on scientific subjects in the German language. " Were all Baron Wolf's other merits disputed, there is one (says Michaëlis), which must incontestably be allowed him, his having added a new degree of perfection to the German Tongue, by applying it to philosophy."—(*Dissertation on the Influence of Opinions on Language*, &c. English Translation, p. 27.)

[3] On the great question of Free Will, Wolfius adopted implicitly the principles of the *Theodicæa;* considering man merely in the light of a *machine;* but (with the author of that work) dignifying this machine by the epithet *spiritual.* This language, which is still very prevalent among German philosophers, may be regarded as a relic of the doctrines of Leibnitz and of Wolfius; and affords an additional proof of the difficulty of eradicating errors sanctioned by illustrious and popular names.

When the system of Pre-established Harmony was first introduced by Wolfius into the University of Halle, it excited an alarm which had very nearly been attended with fatal consequences to the professor. The following anecdote on the subject is told by Euler: " Lorsque du temps du feu Roi de Prusse, M. Wolf enseignoit à Halle le système de l'Harmonie Pré-établie, le Roi s'informa de cette doctrine, qui faisoit grand bruit alors; et un courtisan repondit à sa Majesté, que tous les soldats, selon cette doctrine, n'étoient que des machines; que quand il en désertoit, c'étoit une suite nécessaire de leur structure, et qu'on avoit tort par consequent de les punir, comme on l'auroit si on punissoit une machine pour avoir produit tel ou tel mouvement. Le Roi se facha si fort sur ce rapport, qu'il donna ordre de chasser M. Wolf de Halle, sous peine d'être péndu s'il s'y trouvoit au bout de 24 heurs. Le philosophe se refugia alors à Marbourg, où je lui ai parlé peu de temps après.—(*Lettres à une Princesse d'Allemagne*, Lettre 84me.) We are informed by Condorcet, that some reparation was afterwards made for this injustice by Frederic the Great.—" Le Roi de Prusse, qui ne croit pas pourtant à l'Harmonie Pré-établie, s'est empressé de rendre justice à Wolf dès le premier jour de son regne."

[4] Among other novelties affected by Wolfius, was a new modification of the Theory of the Monads. A slight outline of it, but quite sufficient, I should suppose, to gratify the curiosity of most readers, may be found in Euler's *Letters to a German Princess.*

[5] To what was before remarked, of the opposition in matters of philosophy between the taste of the French and that of the Germans, I shall here add a short passage from an author intimately acquainted with the literature of both nations.

" L'école Allemande reconnoit Leibnitz pour chef. Son fameux disciple Wolf régna dans les universités pendant près d'un demi siècle avec une autorité non contestée. On connoit en France cette philosophie par un grand nombre d'abregés dont quelque-uns sont faits par des auteurs qui seuls auroient suffi pour lui donner de la célébrité.

" Malgré l'appui de tous ces noms, *jamais en France cette philosophie ne s'est soutenue même quelques instans.* La profondeur apparente des idées, l'air d'ensemble et de système, n'ont jamais pu y suppléer à ce qui a paru lui manquer pour en faire une doctrine solide et digne d'être accueillie. Outre quelque défaut de clarté, qui probablement en a écarté des esprits pour qui cette qualité de style et de la pensée est devenue un heureux besoin, la forme sous laquelle elle se présente a rebuté bien des lecteurs. Quoi qu'aient pu faire les interprêtes, il a toujours percé quelque chose de l'appareil incommode qui l'entoure à son origine. Condillac tourne plus d'une fois en ridicule ces formes et ce jargon scientifique, et il s'applique à

From the time of Wolfius till the philosophy of Kant began to attract general notice, I know of no German metaphysician whose speculations seem to have acquired much celebrity in the learned world.[1] Lambert[2] is perhaps the most illustrious name which occurs during this interval. As a mathematician and natural philosopher, his great merits are universally known and acknowledged, but the language in which his metaphysical and logical works were written, has confined their reputation within a comparatively narrow circle. I am sorry that I cannot speak of these from my own knowledge; but I have heard them mentioned in terms of the highest praise, by some very competent judges, to whose testimony I am disposed to give the greater credit, from the singular vein of originality which runs through all his mathematical and physical publications.[3]

The *Critique of Pure Reason* (the most celebrated of Kant's metaphysical works) appeared in 1781.[4] The idea annexed to the title by the author, is thus explained by himself: "Criticam rationis puræ non dico censuram librorum et Systematum, sed facultatis rationalis in universum, respectu cognitionum omnium, ad quas, ab omni experientia libera, possit anniti, proinde dijudicationem possibilitatis aut impossibilitatis metaphysices in genere, constitutionemque tum fontium, tum ambitus atque compagis, tum vero terminorum illius, sed cuncta hæc ex principiis." (Kantii, *Opera ad Philosophiam Criticam*, Vol. I. Præfatio Auctoris Prior. pp. 11, 12.) To render this somewhat more intelligible, I shall subjoin the comment of one of his intimate friends,[5] whose work, we are informed by Dr Willich, had received the sanction of Kant himself. "The aim of Kant's *Critique* is no less than to lead Reason to the true knowledge of itself; to examine the titles upon which it founds the supposed possession of its metaphysical knowledge; and by means of this examination, to mark the true limits, beyond which it cannot venture to speculate, without wandering into the empty region of pure fancy." The same author adds, "The whole *Critique of Pure Reason* is established upon this principle, *that there is a free reason, independent of all experience and sensation.*"

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montrer qu'ils ne sont pas plus propres à satisfaire la raison que le goût. *Il est au moins certain, que le lecteur Français les repousse par instinct, et qu'il y trouve un obstacle très difficile à surmonter.*"—(*Reflexions sur les Œuvres Posthumes d'Adam Smith*, par M. Prevost de Genève, à Paris, 1794.)

[1] Madame de Staël mentions Lessing, Hemsterhuis, and Jacobi, as precursors of Kant in his philosophical career. She adds, however, that they had no school, since none of them attempted to found any system; but they began the war against the doctrines of the Materialists.—(*Allemagne*, Tome III. p. 98.) I am not acquainted with the metaphysical works of any of the three. Those of Hemsterhuis, who wrote wholly in French, were, I understand, first published in a collected form at Paris, in 1792. He was son of the celebrated Greek scholar and critic, Tiberius Hemsterhusius, Professor of Latin Literature at Leyden.

[2] Born at Mulhausen in Alsace in 1728. Died at Berlin in 1777.

[3] The following particulars, with respect to Lambert's literary history, are extracted from a *Memoir* annexed by M. Prevost to his translation of Mr Smith's *Posthumous Works*:—"Cet ingenieux et puissant Lambert, dont les mathematiques, qui lui doivent beaucoup, ne purent épuiser les forces, et qui ne toucha aucun sujet de physique ou de philosophie rationelle, sans le couvrir de lumière. Ses *lettres cosmologiques*, qu'il écrivit par forme de délassement, sont pleines d'idées sublimes, entées sur la philosophie la plus saine et la plus savante tout-à-la-fois. Il avoit aussi dressé sous le titre *d'Architectonique* un tableau des principes sur lesquels se fondent les connoissances humaines. Cet ouvrage au jugement des hommes les plus versés dans l'étude de leur langue, n'est pas exempt d'obscurité. Elle peut tenir en partie à la nature du sujet. Il est à regretter que sa logique, intitulé *Organon*, ne soit traduite ni en Latin, ni en Français, ni je pense en aucune langue. Un extrait bien fait de cet ouvrage, duquel on écarteroit ce qui répugne au goût national, exciteroit l'attention des philosophes, et la porteroit sur une multitude d'objéts qu'ils se sont accoutumés à regarder avec indifférence."—(Prevost, Tome II. pp. 267, 268.)

In the article *Lambert*, inserted in the twenty-third volume of the *Biographie Universelle* (Paris 1819), the following account is given of Lambert's logic:—"Wolf, d'après quelques indications de Leibnitz, avoit retiré de l'oubli la syllogistique d'Aristote, science que les scholastiques avoient tellement avilie que ni Bacon ni Locke n'avoient osé lui accorder un regard d'intéret. Il étoit reservé à Lambert de la montrer sous le plus beau jour et dans la plus riche parure. C'est ce qu'il a fait dans son *Novum Organon*, ouvrage qui est un des principaux titres de gloire de son auteur." From the writer of this article (M. Servois) we farther learn, that the *Novum Organon* of Lambert was translated into Latin from the German original by a person of the name of Pfleiderer, and that this translation was in the hands of an English nobleman (the late Earl of Stanhope) as lately as 1782. I quote the words of M. Servois, in the hope that they may attract some attention to the manuscript, if it be still in existence. The publication of it would certainly be a most acceptable present to the learned world. "D'après le conseil de Le Sage de Geneve, l'ouvrage fut traduit en Latin par Pfleiderer, aux frais d'un savant Italien; cette traduction passa, on ne sait comment, entre les mains de Milord Mahon, qui la possedoit encore en 1782; on ignore quel est son sort ulterieur."

[4] Kant was born at Kœnigsberg, in Prussia, in 1724. He died in 1804.

[5] Mr John Schulze, an eminent divine at Kœnigsberg, author of the *Synopsis of the Critical Philosophy*, translated by Dr Willich, and inserted in his *Elementary View of Kant's Works.*—(See pp. 42, 43.)

When the *Critique of Pure Reason* first came out, it does not seem to have attracted much notice,[1] but such has been its subsequent success, that it may be regarded, according to Madame de Staël,[2] "as having given the impulse to all that has been since done in Germany, both in literature and in philosophy."—*(Allemagne*, Vol. III. pp. 68, 69.)

"At the epoch when this work was published (continues the same writer), there existed among thinking men only two systems concerning the human understanding: The one, that of Locke, ascribed all our ideas to our sensations;[3] the other, that of Descartes and of Leibnitz, had for its chief objects to demonstrate the spirituality and activity of the soul, the freedom of the will,[4] and, in short, the whole doctrines of the idealists. . . . . . Between these extremes rea-

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[1] Il se passa quelque tems après la première publication de la *Critique de la Pure Raison*, sans qu'on fit beaucoup d'attention à ce livre, et sans que la plupart de philosophes, passionés pour l'éclectisme, soupçonassent seulement la grande révolution que cet ouvrage et les productions suivantes de son auteur dévoient opérer dans la science."—(BUHLE, *Hist. de la Phil. Mod.* Tom. VI. p. 573. Paris, 1816.)

As early, however, as the year 1783, the Philosophy of Kant appears to have been adopted in *some* of the German schools. The ingenious M. Trembley, in a memoir then read before the Academy of Berlin, thus speaks of it:—"La philosophie de Kant, qui, *à la honte de l'esprit humain*, paroit avoir acquis tant de faveur dans certaines écoles."—*(Essai sur les Préjugés.* Reprinted at Neufchatel in 1790.)

We are farther told by Buhle, that the attention of the public to Kant's *Critique of Pure Reason* was first attracted by an excellent analysis of the work, which appeared in the *General Gazette of Literature*, and by the *Letters on Kant's Philosophy*, which Reinhold inserted in the *German Mercury*.—(BUHLE, Tom. VI. p. 573.) Of this last philosopher, who appears, in the first instance, to have entered with enthusiasm into Kant's views, and who afterwards contributed much to open the eyes of his countrymen to the radical defects of his system, I shall have occasion to speak hereafter. Degerando, as well as Buhle, bestows high praise not only on his clearness, but on his eloquence, as a writer in his own language. "Il a traduit les oracles Kantiens dans une langue élégante, harmonieuse, et pure * * * Il a su exprimer avec un langage éloquent, des idées jusqu'alors inintelligibles," &c.—*(Histoire Comparée*, &c. Tom. II. p. 271.) That this praise is not undeserved I am very ready to believe, having lately had an opportunity (through the kindness of my learned and revered friend Dr Parr) of reading, in the Latin version of Fredericus Gottolb Born, Reinhold's principal work, entitled *Periculum Novæ Theoriæ Facultatis Repræsentativæ Humanæ.* In point of perspicuity, he appears to me to be greatly superior to Kant; and of this I conceive myself to be not altogether incompetent to judge, as the Latin versions of both authors are by the same hand.

[2] The following quotation, from the advertisement prefixed to Madame de Staël's posthumous work *(Considérations sur la Révolution Française)*, will at once account to my readers for the confidence with which I appeal to her historical statements on the subject of Germany philosophy. Her own knowledge of the language was probably not so critically exact, as to enable her to enter into the more refined details of the different systems which she has described; but her extraordinary penetration, joined to the opportunities she enjoyed of conversing with all that was then most illustrious in Germany, qualified her in an eminent degree to seize and to delineate their great outlines. And if, in executing this task, any considerable mistakes could have been supposed to escape her, we may be fully assured, that the very accomplished person, to whose revision we learn that her literary labours at this period of her life were submitted, would prevent them from ever meeting the public eye. I except, of course, those mistakes into which she was betrayed by her admiration of the German school. Of some of the most important of these, I shall take notice as I proceed; a task which I feel incumbent on me, as it is through the medium of her book that the great majority of English readers have acquired all their knowledge of the new German philosophy, and as her name and talents have given it a temporary consequence in this country which it could not otherwise have acquired.

"Le travail des éditeurs s'est borné uniquement à la révision des épreuves, et à la correction de ces légères inexactitudes de style, qui èchappent à la vue dans le manuscrit le plus soigné. Ce travail c'est fait sous les yeux de *M. A. W. de Schlegel, dont la rare supériorité d'esprit et de savoir justifie la confiance avec laquelle Madame de Staël le consultoit dans tous ses travaux litteraires*, autant que son honorable caractère mérite l'estime et l'amitié qu'elle n'a pas cessé d'avoir pour lui *pendant une liaison de treize années.*"

If any further apology be necessary for quoting a French lady as an authority on German metaphysics, an obvious one is suggested by the extraordinary and well merited popularity of her *Allemagne* in this country. I do not know, if, in any part of her works, her matchless powers have been displayed to greater advantage. Of this no stronger proof can be given than the lively interest she inspires, even when discussing such systems as those of Kant and of Fichte.

[3] That this is a very incorrect account of Locke's philosophy, has been already shown at great length; but in this mistake Madame de Staël has only followed Leibnitz, and a very large proportion of the German philosophers of the present day. "The philosophy of sensation," says Frederick Schlegel, "which was unconsciously bequeathed to the world by Bacon, and reduced to a methodical shape by Locke, first displayed in France the true immorality and destructiveness of which it is the parent, and assumed the appearance of a perfect system of Atheism."—*(Lectures on the History of Literature*, from the German of Fred. Schlegel. Edin. 1818, Vol. II. p. 22.) It is evident, that the system of Locke is here confounded with that of Condillac. May not the former be called the philosophy of *reflection*, with as great propriety as the philosophy of *sensation*?

[4] In considering Leibnitz as a partizan of the freedom of the will, Madame de Staël has also followed the views of many German writers, who make no distinction between Materialists and Necessitarians, imagining, that to assert the spirituality of the soul, is to assert its free agency. On the inaccuracy of these conceptions it would be superfluous to enlarge, after what was formerly said in treating of the metaphysical opinions of Leibnitz.

In consequence of this misapprehension, Madame de Staël, and many other late writers on the Continent, have been led to employ, with a very exceptionable latitude, the word *Idealist*, to comprehend not only the advocates for the immateriality of the mind, but those also who maintain the Freedom of the Human Will. Between these two opinions, there is certainly son continued to wander, till Kant undertook to trace the limits of the two empires; of the senses and of the soul; of the external and of the internal worlds. The force of meditation and of sagacity, with which he marked these limits, had not perhaps any example among his predecessors."—(*Allemagne*, Vol. III. pp. 70, 72.)

The praise bestowed on this part of Kant's philosophy, by one of his own pupils, is not less warm than that of Madame de Staël. I quote the passage, as it enters into some historical details which she has omitted, and describes more explicitly than she has done one of the most important steps, which Kant is supposed by his disciples to have made beyond his predecessors. In reading it, some allowances must be made for the peculiar phraseology of the German school.

"Kant *discovered* that the intuitive faculty of man is a compound of very dissimilar ingredients; or, in other words, that it consists of parts very different in their nature, each of which performs functions peculiar to itself; namely, the *sensitive faculty*, and the *understanding*. . . . . Leibnitz, indeed, had likewise remarked the distinction subsisting between the sensitive faculty and the understanding; but he entirely overlooked the essential difference between their functions, and was of opinion that the faculties differed from one another only in degree. . . . . In the works of the English and French philosophers, we find this essential distinction between the sensitive and the intellectual faculties, and their combination towards producing one synthetical intuition, scarcely mentioned. Locke only alludes to the accidental limitations of both faculties; but to inquire into the essential difference between them does not at all occur to him. . . . . This distinction, then, between the sensitive and the intellectual faculties, forms an essential feature in the philosophy of Kant, and is, indeed, the basis upon which most of his subsequent inquiries are established."—(*Elements of the Crit. Phil.* by A. F. M. WILLICH, M. D. pp. 68, 69, 70.)

It is a circumstance not easily explicable, that, in the foregoing historical sketch, no mention is made of the name of Cudworth, author of the treatise on *Eternal and Immutable Morality;* a book which could scarcely fail to be known, before the period in question, to every German scholar, by the admirable Latin version of it published by Dr Mosheim.[1] In this treatise,

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no necessary connection; Leibnitz, and many other German metaphysicians, denying the latter with no less confidence than that with which they assert the former.

In England, the word *Idealist* is most commonly restricted to such as (with Berkeley) reject the existence of a material world. Of late, its meaning has been sometimes extended (particularly since the publications of Reid) to all those who retain the theory of Descartes and Locke, concerning the immediate objects of our perceptions and thoughts, whether they admit or reject the consequences deduced from this theory by the Berkeleians. In the present state of the science, it would contribute much to the distinctness of our reasonings were it to be used in this last sense exclusively.

There is another word to which Madame de Staël and other writers on the German philosophy annex an idea peculiar to themselves; I mean the word *experimental* or *empirical*. This epithet is often used by them to distinguish what they call the philosophy of Sensations, from that of Plato and of Leibnitz. It is accordingly generally, if not always, employed by them in an unfavourable sense. In this country, on the contrary, the experimental or inductive philosophy of the human mind denotes those speculations concerning mind, which, rejecting all hypothetical theories, rest solely on phenomena for which we have the evidence of consciousness. It is applied to the philosophy of Reid, and to all that is truly valuable in the metaphysical works of Descartes, Locke, Berkeley, and Hume.

Nor are the words, *experimental* and *empirical*, by any means synonymous in our language. The latter word is now almost exclusively appropriated to the practice of Medicine; and when so understood always implies a rash and unphilosophical use of Experience. "The appellation Empiric," says the late Dr John Gregory, "is generally applied to one who, from observing the effects of a remedy in one case of a disease, applies it to all the various cases of that distemper." The same remark may be extended to the word *Empirique* in the French language, which is very nearly synonymous with *Charlatan*. In consequence of this abuse of terms, the epithet *experimental*, as well as *empirical*, is seldom applied by foreign writers to the philosophy of Locke, without being intended to convey a censure.

[1] The first edition of this translation was printed as early as 1732. From Buhle's *History of Modern Philosophy* (a work which did not fall into my hands till long after this section was written), I find that Cudworth's *Treatise of Immutable Morality* is now not only well known to the scholars of Germany, but that some of them have remarked the identity of the doctrines contained in it with those of Kant. "Meiners, dans son histoire générale de l'Ethique, nie que le système morale de Cudworth soit identique avec celui de Platon, et prétend au contraire, 'que les principes considérés comme appartenans de la manière la plus spéciale à la morale de Kant, étaient enseignés il y a deja plusieurs générations par l'école du philosophe Anglais."—(*Hist. de la Phil. Moderne*, Tom. III. p. 577.) In opposition to this, Buhle states his own decided conviction, "qu' aucune des idées de Cudworth ne se rapproche de celles de Kant."—(*Ibid.*) How far this conviction is well founded, the passage from Cudworth, quoted in the text, will enable my readers to judge for themselves.

That Cudworth has blended with his principles a vein of Platonic mysticism, which is not to be found in Kant, is undeniable; but it does not follow from this, that none of Kant's leading ideas are borrowed from the writings of Cudworth.

The assertion of Buhle, just mentioned, is the more surprising, as he himself acknowledges that "la philosophie

Cudworth is at much pains to illustrate the Platonic doctrine concerning the difference between sensation and intellection; asserting that "some ideas of the mind proceed not from outward sensible objects, but arise from the inward activity of the mind itself;" that "even simple corporeal things, passively perceived by sense, are known and understood only by the active power of the mind;" and that, besides Αισθηματα and Φαντασματα, there must be Νοηματα or intelligible ideas, the source of which can be traced to the understanding alone.[1]

In the course of his speculations on these subjects, Cudworth has blended, with some very deep and valuable discussions, several opinions to which I cannot assent, and not a few propositions which I am unable to comprehend; but he seems to have advanced at least as far as Kant, in drawing the line between the provinces of the senses and of the understanding; and although not one of the most luminous of our English writers, he must be allowed to be far superior to the German metaphysician, both in point of perspicuity and of precision. A later writer, too, of our own country (Dr Price), a zealous follower both of Plato and of Cudworth, afterwards resumed the same argument, in a work which appeared long before the *Critique of Pure Reason*;[2] and urged it with much force against those modern metaphysicians, who consider the senses as the sources of all our knowledge. At a period somewhat earlier, many very interesting quotations of a similar import had been produced by the learned Mr Harris, from the later commentators of the Alexandrian school on the philosophy of Aristotle; and had been advantageously contrasted by him with the account given of the origin of our ideas, not only by Hobbes and Gassendi, but by many of the professed followers of Locke. If this part of the Kantian system, therefore, was new in Germany, it certainly could have no claim to the praise of originality, in the estimation of those at all acquainted with English literature.[3]

In order, however, to strike at the root of what the Germans call the *philosophy of sensa-*

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morale de Price présente en effet une analogie frappante avec celle de Kant;" and in another part of his work, he expresses himself thus on the same subject: "Le plus remarquable de tous les moralistes modernes de l'Angleterre est, sans contredit, Richard Price......On remarque l'analogie la plus frappante entre ses idées sur les bases de la moralite, et celles que la philosophie critique à fait naitre en Allemagne, quoique il ne soit cependant pas possible d'élever le plus petit doute sur l'entière originalité de ces dernières."—(Tom. V. p. 303.) Is there any thing of importance in the system of Price, which is not borrowed from the *Treatise of Immutable Morality*? The distinguishing merit of this learned and most respectable writer is the good sense with which he has applied the doctrines of Cudworth to the sceptical theories of his own times.

In the sequel of Buhle's reflections on Cudworth's philosophy, we are told, that, according to him, "the will of God is only a simple blind power, acting mechanically or accidentally." ("Chez Cudworth la volonté même en Dieu, n'est qu'un simple pouvoir aveugle, agissant méchaniquement ou accidentellement.") If this were true, Cudworth ought to be ranked among the disciples, not of Plato, but of Spinoza.

[1] In this instance, a striking resemblance is observable between the language of Cudworth and that of Kant; both of them having followed the distinctions of the Socratic school, as explained in the *Theætetus* of Plato. They who are at all acquainted with Kant's *Critique*, will immediately recognise his phraseology in the passage quoted above.

[2] See a review of the *Principal Questions and Difficulties relating to Morals*, by Richard Price, D. D. London, 1758.

[3] I have mentioned here only those works of a modern date, which may be reasonably presumed to be still in general circulation among the learned. But many very valuable illustrations of the Platonic distinction between the senses and the understanding may be collected from the English writers of the seventeenth century. Among these it is sufficient to mention at present the names of John Smith and Henry More of Cambridge, and of Joseph Glanvile, the author of *Scepsis Scientifica*.

Cudworth's *Treatise of Eternal and Immutable Morality*, although it appears, from intrinsic evidence, to have been composed during the lifetime of Hobbes, was not published till 1731, when the author's manuscript came into the hands of his grandson, Francis Cudworth Masham, one of the Masters in Chancery. This work, therefore, could not have been known to Leibnitz, who died seventeen years before; a circumstance which may help to account for its having attracted so much less attention in Germany than his *Intellectual System*, which is repeatedly mentioned by Leibnitz in terms of the highest praise.

From an article in the *Edinburgh Review* (Vol. XXVII. p. 191), we learn, that large unpublished manuscripts of Dr Cudworth are deposited in the British Museum. It is much to be regretted (as the author of the article observes), that they should have been so long withheld from the public. "The press of the two Universities (he adds) would be properly employed in works, which a commercial publisher could not prudently undertake." May we not indulge a hope, that this suggestion will, sooner or later, have its due effect?

In the preface of Mosheim to his Latin version of the *Intellectual System*, there is a catalogue of Cudworth's unpublished remains, communicated to Mosheim by Dr Chandler, then Bishop of Durham. Among these are two distinct works on the Controversy concerning Liberty and Necessity, of each of which works Mosheim has given us the general contents. One of the chapters is entitled, "Answer to the Objection against Liberty, *μηδεν αναιτιον*." It is not probable that it contains any thing very new or important; but it would certainly be worth while to know the reply made by Cudworth to an objection which both Leibnitz and La Place have fixed upon as decisive of the point in dispute.

tion, it was necessary to trace, with some degree of systematical detail, the origin of our most important *simple notions;* and for this purpose it seemed reasonable to begin with an analytical view of those faculties and powers, to the exercise of which the development of these notions is necessarily subsequent. It is thus that the simple notions of *time* and *motion* presuppose the exercise of the faculty of memory; and that the simple notions of *truth*, of *belief*, of *doubt*, and many others of the same kind, necessarily presuppose the exercise of the power of reasoning. I do not know, that, in this anatomy of the mind, much progress has hitherto been made by the German metaphysicians. A great deal certainly has been accomplished by the late Dr Reid; and something, perhaps, has been added to his labours by those of his successors.

According to Kant himself, his metaphysical doctrines first occurred to him while employed in the examination of Mr Hume's *Theory of Causation*. The train of thought by which he was led to them will be best stated in his own words; for it is in this way alone that I can hope to escape the charge of misrepresentation from his followers. Some of his details would perhaps have been more intelligible to my readers, had my plan allowed me to prefix to them a slight outline of Hume's philosophy. But this the general arrangement of my discourse rendered impossible; nor can any material inconvenience result, in this instance, from the order which I have adopted, inasmuch as Hume's *Theory of Causation*, how new soever it may have appeared to Kant, is fundamentally the same with that of Malebranche, and of a variety of other old writers, both French and English.

[1] "Since the *Essays* (says Kant) of Locke and of Leibnitz, or rather since the origin of metaphysics, as far as their history extends, no circumstance has occurred, which might have been more decisive of the fate of this science than the attack made upon it by David Hume.[2] He proceeded upon a single but important idea in metaphysics, the connection of cause and effect, and the concomitant notions of power and action. He challenged *reason* to answer him what title she had to imagine, that any thing may be so constituted as that, if it be given, something else is also thereby inferred; for the idea of cause denotes this. He proved beyond contradiction, that it is impossible for reason to think of such a connection *a priori*, for it contains *necessity;* but it is not possible to perceive how, because something is, something else must necessarily be; nor how the idea of such a connection can be introduced *a priori*.

"Hence, he concluded, that reason entirely deceives herself with this idea, and that she erroneously considers it as her own child, when it is only the spurious offspring of imagination, impregnated by experience; a *subjective* necessity, arising from habit and the association of ideas, being thus substituted for an *objective* one derived from perception....However hasty and unwarrantable Hume's conclusion might appear, yet it was founded upon investigation; and this investigation well deserved, that some of the philosophers of his time should have united to solve, more happily if possible, the problem in the sense in which he delivered it: A complete reform of the science might have resulted from this solution. But it is a mortifying reflection, that his opponents, Reid, Beattie, Oswald, and, lastly, Priestley himself, totally misunderstood the *tendency* of his problem.[3] The question was not, whether the idea of cause be in itself proper and indispensable to the illustration of all natural knowledge, for this Hume had never doubted; but whether this idea be an object of thought through reasoning *a priori;* and whether, in this manner, it possesses internal evidence, independently of all experience; consequently, whether its utility be not limited to objects of sense alone. It was upon this point that Hume expected an explanation.[1]

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[1] See the Preface of Kant to one of his Treatises, entitled *Prolegomena ad Metaphysicam quamque futuram quæ qua Scientia poterit prodire.* I have availed myself in the text of the English version of Dr Willich, from the German original, which I have carefully compared with the Latin version of Born. A few sentences, omitted by Willich, I have thought it worth while to quote, at the foot of the page, from the Latin translation.—(*Elem. of Critical Philosophy*, by A. F. M. WILLICH, M. D. p. 10. *et seq.* London, 1798.)

[2] "*Humius.*—Qui quidem nullam huic cognitionis parti lucem adfudit, sed tamen excitavit scintillam, de qua sane lumen potuisset accendi, si ea incidisset in fomitem, facile accipientem, cujusque scintillatio diligenter alta fuerit et aucta."

[3] "Non potest sine certo quodam molestiæ sensu percipi, quantopere ejus adversarii, *Reidius*, *Oswaldus*, *Beattius*, et tandem *Priestleius*, a scopo quæstionis aberrarent, et propterea quod ea semper acciperent pro concessis, quæ ipse in dubium vocaret, contra vero cum vehementia, et maximam partem cum ingenti immodestia ea probare gestirent, quæ illi nunquam in mentem venisset dubitare, *nutum* ejus ad emendationem ita negligerent, ut omnia in statu pristino maneret, quasi nihil quidquam factum videretur."

"I freely own it was these suggestions of Hume's which first, many years ago, roused me from my dogmatical slumber, and gave to my inquiries quite a different direction in the field of speculative philosophy. I was far from being carried away by his conclusions, the fallacy of which chiefly arose from his not forming to himself an idea of the *whole of his problem*, but merely investigating a part of it, the solution of which was impossible without a comprehensive view of the whole. When we proceed on a well founded, though not thoroughly digested thought, we may expect, by patient and continued reflection, to prosecute it farther than the acute genius had done to whom we are indebted for the first spark of this light. I first inquired, therefore, whether Hume's objection might not be a general one, and soon found, that the idea of cause and effect is far from being the only one by which the understanding *a priori* thinks of the connection of things; but rather that the science of metaphysics is altogether founded upon these connections. I endeavoured to ascertain their number; and, having succeeded in this attempt, I proceeded to the examination of those general ideas, which, I was now convinced, are not, as Hume apprehended, derived from experience, but arise out of the pure understanding. This deduction, which seemed impossible to my acute predecessor, and which nobody besides him had ever conceived, although every one makes use of these ideas, without asking himself upon what their objective validity is founded; this deduction, I say, was the most difficult which could have been undertaken for the behoof of metaphysics; and what was still more embarrassing, metaphysics could not here offer me the smallest assistance, because that deduction ought first to establish the possibility of a system of metaphysics. As I had now succeeded in the explanation of Hume's problem, not merely in a particular instance, but with a view of the whole power of pure reason, I could advance with sure though tedious steps, to determine completely, and upon general principles, the compass of Pure Reason, both what is the sphere of its exertion, and what are its limits; which was all that was required for erecting a system of metaphysics upon a proper and solid foundation."

It is difficult to discover any thing in the foregoing passage on which Kant could found a claim to the slightest originality. A variety of English writers had, long before this work appeared, replied to Mr Hume, by observing that the understanding is itself a source of new ideas, and that it is from this source that our notions of cause and effect are derived. "Our certainty (says Dr Price) that every new event requires some cause, depends no more on experience than our certainty of any other the most obvious subject of intuition. In the idea of every *change*, is included that of its being an *effect*."[2] In the works of Dr Reid, many remarks of the same nature are to be found; but, instead of quoting any of these, I shall produce a passage from a much older author, whose mode of thinking and writing may perhaps be more agreeble to the taste of Kant's countrymen than the simplicity and precision aimed at by the disciples of Locke.

"That there are some ideas of the mind (says Dr Cudworth), which were not stamped or imprinted upon it from the sensible objects without, and therefore must needs arise from the innate vigour and activity of the mind itself, is evident, in that there are, *First*, Ideas of such things as are neither affections of bodies, nor could be imprinted or conveyed by any local motions, nor can be pictured at all by the fancy in any sensible colours; such as are the ideas of wisdom, folly, prudence, imprudence, knowledge, ignorance, verity, falsity, virtue, vice, honesty, dishonesty, justice, injustice, volition, cogitation, nay of sense itself, which is a species of cogitation, and which is not perceptible by any sense; and many other such like notions as include something of cogitation in them, or refer to cogitative beings only; which ideas must needs spring from the active power and innate fecundity of the mind itself,[1] because the corporeal objects of sense can imprint no such things upon it. *Secondly*, In that there are many relative notions and ideas, attributed as well to corporeal as incorporeal things, that proceed wholly from the activity of the mind comparing one thing with another. Such as are Cause, Effect, means, end, order, proportion, similitude, dissimilitude, equality, inequality, aptitude, inaptitude, symmetry, asymmetry, whole and part, genus and species, and the like." *Immutable Morality*, pp. 148, 149.

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[1] Although nothing can be more unjust than these remarks, in the unqualified form in which they are stated by Kant, it must, I think, be acknowledged, that some grounds for them have been furnished by occasional passages which dropped from the pens of most of Mr Hume's Scottish opponents.

[2] *Review of the Principal Questions and Difficulties in Morals*, Chap. i. sect. 2. The first edition of this book was printed in 1758.

It is not my business at present to inquire into the solidity of the doctrine here maintained. I would only wish to be informed what additions have been made by Kant to the reply given to Mr Hume by our English philosophers, and to direct the attention of my readers to the close resemblance between this part of Kant's system, and the argument which Cudworth opposed to Hobbes and Gassendi considerably more than a century ago.[2]

The following passage, from the writer last quoted, approaches so nearly to what Kant and other Germans have so often repeated of the distinction between *subjective* and *objective* truth, that I am tempted to connect it with the foregoing extract, as an additional proof that there are, at least, some metaphysical points, on which we need not search for instruction beyond our own island.

" If there were no other perceptive power, or faculty, distinct from external sense, all our perceptions would be merely relative, seeming, and fantastical, and not reach to the absolute and certain truth of any thing; and every one would but, as Protagoras expounds, 'think his own private and relative thoughts truths,' and all our cogitations being nothing but appearances, would be indifferently alike true phantasms, and one as another.

" But we have since also demonstrated, that there is another perceptive power in the soul superior to outward sense, and of a distinct nature from it, which is the power of knowing or understanding, that is, an active exertion from the mind itself. And, therefore, has this grand eminence above sense, that it is no idiopathy, not a mere private, relative, seeming, and fantastical thing, but the comprehension of that which absolutely is and is not."[3]

After enlarging on the distinction between the sensitive faculty and the understanding, Kant proceeds to investigate certain essential conditions, without which neither the sensitive faculty nor its objects are conceivable. These conditions are *time* and *space*, which, in the language of Kant, are the *forms* of all phenomena. What his peculiar ideas are concerning their nature and attributes, my readers will find stated in his own words at the end of this Discourse, in an extract from one of his Latin publications.[4] From that extract, I cannot promise them much instruction; but it will at least enable them to judge for themselves of the peculiar character of Kant's metaphysical phraseology. In the mean time, it will be sufficient to mention here, for the sake of connection, that he denies the *objective* reality both of time and of space. The former he considers merely as a *subjective* condition, inseparably connected with the frame of the human mind, in consequence of which, it arranges sensible phenomena according to a certain law, in the order of succession. As to the latter, he asserts, that it is nothing *objective* or *real*, inasmuch as it is neither a substance, nor an accident, nor a relation; that its existence, therefore, is only *subjective* and *ideal*, depending on a fixed law, inseparable from the frame of the human mind. In consequence of this law, we are led to conceive all external things as placed in space; or, as Kant expresses it, we are led to consider *space as the fundamental form of every external sensation.*

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[1] This is precisely the language of the German school: " Les verités necessaires, " says Leibnitz, " sont le produit immediat de l'activité interieure."—(Tome I. p. 686. Tome II. pp. 42, 325. See Degerando, *Hist. Comp.* Tome II. p. 96.)

[2] In the attempt, indeed, which Kant has made to enumerate all the general ideas which are not derived from experience, but arise out of the pure understanding, he may well lay claim to the praise of originality. On this subject I shall only refer my readers to Note X X at the end of this *Dissertation*.

[3] *Immutable Morality*, p. 264, *et seq.*

[4] See Note Y Y.

In selecting Kant's speculations concerning *time* and *space*, as a specimen of his mode of writing, I was partly influenced by the consideration, that it furnishes, at the same time, a remarkable example of the concatenation which exists between the most remote and seemingly the most unconnected parts of his system. Who could suppose that his opinions on these subjects, the most abstract and the most controverted of any in the whole compass of metaphysics, bore on the great practical question of the freedom of the Human Will? The combination appears, at first sight, so very extraordinary, that I have no doubt I shall gratify the curiosity of some of my readers by mentioning a few of the intermediate steps which, in this argument, lead from the premises to the conclusion.

That Kant conceived the free agency of man to be necessarily implied in his moral nature (or, at least, that he was anxious to offer no violence to the common language of the world on this point), appears from his own explicit declarations in various parts of his works. "Voluntas libera (says he in one instance) eadem est cum voluntate legibus moralibus obnoxia."[1]

In all the accounts of Kant's philosophy, which have yet appeared from the pens of his admirers in this country, particular stress is laid on the ingenuity with which he has unloosed this knot, which had baffled the wisdom of all his predecessors. The following are the words of one of his own pupils, to whom we are indebted for the first, and, I think, not the least intelligible, view of his principles, which has been published in our language.[2]

"Professor Kant is decidedly of opinion, that although many strong and ingenious arguments have been brought forward in favour of the freedom of the will, they are yet very far from being decisive. Nor have they refuted the arguments urged by the Necessitarians, but by an appeal to mere feeling, which, on such a question, is of no avail. For this purpose, it is indispensably necessary to call to our assistance the principles of Kant."

"In treating this subject (continues the same author), Kant begins with showing that the notion of a Free Will is not contradictory. In proof of this he observes, that, although every human action, as an event in time, must have a cause, and so on *ad infinitum;* yet it is certain, that the laws of cause and effect can have a place there only where *time* is, for the effect must be consequent on the cause. But neither *time* nor *space* are properties of things; they are only the general *forms* under which man is allowed to view himself and the world. It follows, therefore, that man is not in time nor in space, although the forms of his intuitive ideas are time and space. But if man exist not in time and space, he is not influenced by the laws of time and space, among which those of cause and effect hold a distinguished rank; it is, therefore, no contradiction to conceive, that, in such an order of things, man may be free."[3]

In this manner Kant establishes the *possibility* of man's freedom; and, farther than this, he does not conceive himself warranted to proceed on the principles of the critical philosophy. The first impression, certainly, which his argument produces on the mind is, that his own opinion was favourable to the scheme of necessity. For if the reasonings of the Necessitarians be admitted to be satisfactory, and if nothing can be opposed to them but the incomprehensible proposition, that man neither exists in space nor in time, the natural inference is, that this proposition was brought forward rather to save appearances, than as a serious objection to the universality of the conclusion.

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[1] See Born's Latin Translation of Kant's Works, relating to the *Critical Philosophy*, Vol. II. p. 325, *et seq.* See also the Preface to Vol. III.

[2] *A General and Introductory View of Professor Kant's Principles concerning Man, the World, and the Deity, submitted to the consideration of the Learned*, by F. A. NITSCH, late Lecturer on the Latin Language and Mathematics in the Royal Fredericianum College at Königsberg, and pupil of Professor Kant. London, 1796. Pp. 172, 173.

This small performance is spoken of in terms highly favourable, by the other writers who have attempted to introduce Kant's philosophy into England. It is called by Dr Willich *an excellent publication (Elements of the Critical Philosophy*, p. 62.); and is pronounced by the author of the elaborate articles on that subject in the *Encyclopædia Londonensis* to be a *sterling work.* "Though at present very little known, I may venture," says this writer, "to predict, that, as time rolls on, and prejudices moulder away, this work, like the *Elements of Euclid*, will stand forth as a lasting monument of PURE TRUTH."—See Note *Z Z.*

[3] NITSCH, &c. pp. 174, 175.

Here, however, Kant calls to his aid the principles of what he calls *practical* reason. Deeply impressed with a conviction that morality is the chief concern of man, and that morality and the freedom of the human will must stand or fall together, he exerts his ingenuity to show, that the metaphysical proof already brought of the possibility of free agency, joined to our own consciousness of a liberty of choice, affords evidence of the fact fully sufficient for the practical regulation of our conduct, although not amounting to what is represented as demonstration in the *Critique of Pure Reason.*[1]

It is impossible to combine together these two parts of the Kantian system, without being struck with the resemblance they bear to the deceitful sense of liberty to which Lord Kames had recourse (in the *first* edition of his *Essays on Morality and Natural Religion*), in order to reconcile our consciousness of free agency with the conclusions of the Necessitarians. In both cases, the reader is left in a state of most uncomfortable scepticism, not confined to this particular question, but extending to every other subject which can give employment to the human faculties.[2]

In some respects, the functions ascribed by Kant to his *practical* reason are analogous to those ascribed to common sense in the writings of Beattie and Oswald. But his view of the subject is, on the whole, infinitely more exceptionable than theirs, inasmuch as it sanctions the supposition, that the conclusions of *pure reason* are, in certain instances, at variance with *that* modification of reason which was meant by our Maker to be our guide in life; whereas the constant language of the other writers is, that all the different parts of our intellectual frame are in the most perfect harmony with each other. The motto which Beattie has prefixed to his book,

> " Nunquam aliud natura, aliud sapientia dicit,'

expresses, in a few significant words, the whole substance of his philosophy.

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[1] The account of this part of Kant's doctrine given by M. Buhle agrees in substance with that of Mr Nitsch: " Toute moralité des actions repose uniquement sur la disposition practique, en tant qu'elle est déterminée par la loi morale seule. Si l'on considére cette disposition comme *phénomène* dans la conscience; c'est un événement naturel, elle obéit à la loi de la causalité, elle repose sur ce que l'homme a éprouvé auparavant dans le tems, et elle fait partie du caractère empirique de l'homme. Mais on peut aussi la considérer comme un acte de la liberté raisonnable: Alors elle n'est plus soumise à la loi de la causalité; elle est indépendante de la condition du temps, elle se rapporte à une cause intelligible, la liberté, et elle fait partie du caractère intelligible de l'homme. On ne peut, à la vérité, point acquerir la moindre connoissance des objets intelligibles; mais la liberté n'est pas moins un fait de la conscience. Donc les actions extérieures sont indifférentes pour la moralité de l'homme. La bonté morale de l'homme consiste uniquement dans sa volonté moralement bonne, et celle-ci consiste en ce que la volonté soit déterminée par la loi morale seule."—*(Hist. de la Philosophie Moderne*, par J. G. BUHLE, Tom. VI. pp. 504, 505.)

Very nearly to the same purpose is the following statement by the ingenious author of the article *Leibnitz* in the *Biographie Universelle*:—" Comment accorder le *fatum* et la liberté, l'imputation morale et la dépendence des êtres finies? Kant croit échapper à cet écueil en ne soumettant à la loi de causalité (au *déterminisme* de Leibnitz) que le monde phénoménique, et en affranchissant de ce principe l'âme comme *noumène* ou chose en soi, envisageant ainsi chaque action comme appartenant à un double serie à la fois; à l'ordre physique où elle est enchainée à ce qui precède et à ce qui suit par les liens communs de la nature, et à l'ordre morale, où une détermination produit un effet, sans que pour expliquer cette volition et son resultat, on soit renvoyé à un état antécédent."

The author of the above passage is M. Staffer, to whom we are indebted for the article *Kant* in the same work. For Kant's own view of the subject consult his *Critique of Pure Reason*, *passim*, particularly p. 99. *et seq.* of Born's *Translation*, Vol. III.

[2] The idea of Kant (according to his own explicit avowal) was, that every being, which *conceives* itself to be free, whether it be in reality so or not, is rendered by its own belief a moral and accountable agent. " Jam equidem dico: quæque natura, quæ non potest nisi *sub idea libertatis* agere, propter id ipsum, respectu practico, reipsa libera est; hoc est, ad eam valent cunctæ leges, cum libertate arctissime conjunctæ perinde, ac voluntas ejus etiam per se ipsam, et in philosophia theoretica probata, libera declaretur.—(KANTII *Opera*, Vol. II. p. 326.)

This is also the creed professed by the Abbé Galiani, a much more dangerous moralist than Kant, because he is always intelligible, and often extremely lively and amusing. " L'homme est donc libre, puisqu'il est intimement persuadé de l'être, et que cela vaut tout autant que la liberté. *Voila donc le méchanisme de l'univers expliqué clair comme de l'eau de roche.*" The same author farther remarks, " La persuasion de la liberté constitue l'essence de l'homme. On pourroit même définir l'homme *un animal qui se croit libre*, et ce seroit une définition complète."—*(Correspondance de l'Abbé Galiani*, Tome I. pp. 339, 340. A Paris, 1818.)

It is to the same *practical* modification of reason that Kant appeals in favour of the existence of the Deity, and of a future state of retribution, both of which articles of belief he thinks derive the whole of their evidence from the moral nature of man. His system, therefore, as far as I am able to comprehend it, tends rather to represent these as useful *credenda*, than as certain or even as probable truths. Indeed, the whole of his moral superstructure will be found to rest ultimately on no better basis than the metaphysical *conundrum*, that the human mind (considered as a *noumenon* and not as a *phenomenon*) neither exists in space nor in time.

That it was Kant's original aim to establish a system of scepticism, I am far from being disposed to think.[1] The probability is, that he began with a serious wish to refute the doctrines of Hume; and that, in the progress of his inquiries, he met with obstacles of which he was not aware. It was to remove these obstacles that he had recourse to practical reason; an idea which has every appearance of being an *afterthought*, very remote from his views when he first undertook his work. This, too, would seem, from the following passage (which I translate from Degerando), to have been the opinion of one of Kant's ablest German commentators, M. Reinhold: " *Practical Reason* (as Reinhold ingeniously observes) is a wing which Kant has prudently added to his edifice, from a sense of the inadequacy of the original design to answer the intended purpose. It bears a manifest resemblance to what some philosophers call an appeal to *sentiment*, founding belief on the necessity of acting. Whatever contempt Kant may affect for popular systems of philosophy, this manner of considering the subject is not unlike the disposition of those who, feeling their inability to obtain, by the exercise of their reason, a direct conviction of their religious creed, cling to it nevertheless with a blind eagerness, as a support essential to their morals and their happiness." (*Hist. Comparée*, Vol. II. pp. 243, 244.)

The extraordinary impression produced for a considerable time in Germany, by the *Critique of Pure Reason*, is very shrewdly, and I suspect justly, accounted for by the writer last quoted: " The system of Kant was well adapted to flatter the weaknesses of the human mind. Curiosity was excited, by seeing paths opened which had never been trodden before. The love of mystery found a secret charm in the obscurity which enveloped the doctrine. The long and troublesome period of initiation was calculated to rouse the ambition of bold and adventurous spirits. Their love of singularity was gratified by the new nomenclature; while their vanity exulted in the idea of being admitted into a privileged sect, exercising, and entitled to exercise, the supreme censorship in philosophy. Even men of the most ordinary parts, on finding themselves called to so high functions, lost sight of their real mediocrity, and conceived themselves transformed into geniuses destined to form a new era in the history of reason.

" Another inevitable effect resulted from the universal change operated by Kant in his terms, in his classifications, in his methods, and in the enunciation of his problems. The intellectual powers of the greater part of the initiated were too much exhausted in the course of their long noviciate, to be qualified to judge soundly of the doctrine itself. They felt themselves, after so many windings, lost in a labyrinth, and were unable to dispense with the assistance of the guide who had conducted them so far. Others, after so great a sacrifice, wanted the courage to confess to the world, or to themselves, the disappointment they had met with. They attached themselves to the doctrine in proportion to the sacrifice they had made, and estimated its value by the labour it had cost them. As for more superficial thinkers, they drew an inference from the novelty of the form in favour of the novelty of the matter, and from the novelty of the matter in favour of its importance.

" It is a great advantage for a sect to possess a distinguishing garb and livery. It was thus that the Peripatetics extended their empire so widely, and united their subjects in one common obedience. Kant had, over and above all this, the art of insisting, that his disciples should belong exclusively to himself. He explicitly announced, that he was not going to found a school of Eclectics, but a school of his own; a school not only independent, but in some measure hostile to every other; that he could admit of no compromise with any sect whatever; that he was come to overturn every thing which existed in philosophy, and to erect a new edifice on these immense ruins. The more decided and arrogant the terms were in which he announced his design, the more likely was it to succeed; for the human mind submits more easily to an unlimited than to a partial faith, and yields itself up without reserve, rather than consent to cavil about restrictions and conditions even in favour of its own independence."

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[1] On the contrary, he declares explicitly (and I give him full credit for the sincerity of his words), that he considered his *Critique of Pure Reason* as the only effectual antidote against the opposite extremes of scepticism and of superstition, as well as against various heretical doctrines which at present infect the schools of philosophy. " Hac igitur sola (*Philosophia Critica*) et materialismi, et fatalismi, et Atheismi, et diffidentiæ profanæ, et fanatismi, et superstitionis, quorum virus ad universos potest penetrare, tandemque etiam et idealismi et scepticismi, qui magis scholis sunt pestiferi, radices ipsæ possunt præcidi."—(KANT, *Præf. Posterior*, p. 35.)

With these causes of Kant's success another seems to have powerfully conspired; the indissoluble coherence and concatenation of all the different parts of his philosophy. "It is on this concatenation (says M. Prevost) that the admiration of Kant's followers is chiefly founded." *Grant only* (they boast) *the first principles of the Critical Philosophy, and you must grant the whole system.* The passage quoted on this occasion by M. Prevost is so forcibly expressed, that I cannot do it justice in an English version: "Ab hinc enim capitibus fluere necesse est omnem philosophiæ criticæ rationis puræ vim atque virtutem; namque in ea contextus rerum prorsus mirabilis est, ita ut extrema primis, media utrisque, omnia omnibus respondeant; si prima dederis danda sunt omnia."[1] No worse account could well have been given of a philosophical work on such a subject; nor could any of its characteristical features have been pointed out more symptomatic of its ephemeral reputation. Supposing the praise to be just, it represented the system, however fair and imposing in its first aspect, as vitally and mortally vulnerable (if at all vulnerable) in every point; and, accordingly, it was fast approaching to its dissolution before the death of its author. In Germany, at present, we are told, that a pure Kantian is scarcely to be found.[2] But there are many Semi-Kantians and Anti-Kantians, as well as partisans of other schemes built out of the ruins of the Kantian philosophy.[3] "In fine (says a late author), the *Critique of Pure Reason*, announced with pomp, received with fanaticism, disputed about with fury, after having accomplished the overthrow of the doctrines taught by Leibnitz and Wolff, could no longer support itself upon its own foundations, and has produced no permanent result, but divisions and enmities, and a general disgust at all systematical creeds."[4] If this last effect has really resulted from it (of which some doubts may perhaps be entertained), it may be regarded as a favourable symptom of a sounder taste in matters of abstract science, than has ever yet prevailed in that country.[5]

To these details, I have only to add a re-

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[1] See some very valuable strictures on Kant, in the learned and elegant sketch of the present state of philosophy, subjoined to M. Prevost's French translation of Mr Smith's posthumous works. The Latin panegyric on the critical philosophy is quoted from a work with which I am unacquainted, *Fred. Gottlob Bornii de Scientia et Conjectura.*

[2] On this subject, see Degerando, Tom. II. p. 333.

[3] See Degerando and De Bonald.

[4] The words in the original are, "Un dégôut générale de toute doctrine." But as the same word *doctrine* is, in a former part of the same sentence, applied to the systems of Leibnitz and of Wolff, I have little doubt, that, in substituting for *doctrine* the phrase *systematical creeds*, I have faithfully rendered the meaning of my author.—(See *Recherches Philosophiques*, par M. De Bonald, Tom. I. pp. 43, 44.)

[5] The passion of the Germans for *systems* is a striking feature in their literary taste, and is sufficient of itself to show, that they have not yet passed their noviciate in philosophy. "To all such (says Mr Maclaurin) as have just notions of the Great Author of the Universe, and of his admirable workmanship, all complete and finished systems must appear very suspicious." At the time when he wrote, such systems had not wholly lost their partisans in England; and the name of *System* continued to be a favourite title for a book even among writers of the highest reputation. Hence the *System of Moral Philosophy* by Hutcheson, and the *Complete System of Optics* by Smith, titles which, when compared with the subsequent progress of these two sciences, reflect some degree of ridicule upon their authors.

When this affectation of systematical method began, in consequence of the more enlarged views of philosophers, to give way to that aphoristical style so strongly recommended and so happily exemplified by Lord Bacon, we find some writers of the old school complaining of the innovation, in terms not unlike those in which the philosophy of the English has been censured by some German critics. "The best way (says Dr Watts) to learn any science, is to begin with a regular sysmark of Degerando's, which I have found amply confirmed within the circle of my own experience. It might furnish matter for some useful reflections, but I shall leave my readers to draw their own conclusions from it. "Another remarkable circumstance is, that the defence of the Kantians turned, in general, not upon the *truth* of the disputed proposition, but upon the right interpretation of their master's meaning, and that their reply to all objections has constantly begun and ended with these words, *You have not understood us.*"

Among the various schools which have emanated from that of Kant, those of Fichte and Schelling seem to have attracted among their countrymen the greatest number of proselytes. Of neither am I able to speak from my own knowledge; nor can I annex any distinct idea to the accounts which are given of their opinions by others. Of Fichte's speculations about the philosophical import of the pronoun *I* (*Qu'est-ce que le moi?* as Degerando translates the question), I cannot make any thing. In some of his remarks, he approaches to the language of those Cartesians who, in the progress of their doubts, ended in absolute *egoism*: but the *ego*[1] of Fichte has a creative power. It creates *existence*, and it creates *science*; two things (by the way) which, according to him, are one and the same. Even *my own* existence, he tells me, commences only with the *reflex act*, by which I think of the pure and primitive *ego*. On this identity of the intelligent *ego* and the existing *ego* (which Fichte expresses by the formula ego = ego) all science ultimately rests.—But on this part of his metaphysics it would be idle to enlarge, as the author acknowledges, that it is not to be understood without the aid of a certain *transcendental sense*, the want of which is wholly irreparable; a singular admission enough (as Degerando observes), on the part of those critical philosophers who have treated with so much contempt the appeal to *Common Sense* in the writings of some of their predecessors.[2]

"In the history of beings there are (according to Fichte) three grand epochs; the first belongs to the empire of *chance;* the second is the reign of *nature;* the third *will be* the epoch of the existence of *God.* For God does not exist yet; he only manifests himself as preparing to exist. Nature tends to an apotheosis, and may be regarded as a sort of divinity in the germ."[3]

The account given by Madame de Staël of this part of Fichte's system is considerably different: "He was heard to say, upon one occasion, that in his next lecture he 'was going to create God,'—an expression which, not without reason, gave general offence. His meaning was, that he intended to show how the idea of God arose and unfolded itself in the mind of man."[4] How far this apology is well-founded, I am not competent to judge.

The system of Schelling is, in the opinion of Degerando, but an extension of that of Fichte; connecting with it a sort of Spinozism grafted on Idealism. In considering the primitive *ego*

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tem. Now (he continues), we deal much in essays, and unreasonably despise systematical learning; whereas our fathers had a just value for regularity and systems." Had Dr Watts lived a few years later, I doubt not that his good sense would have led him to retract these hasty and inconsiderate decisions.

[1] In order to avoid the intolerable aukwardness of such a phrase as *the I*, I have substituted on this occasion the Latin pronoun for the English one.

[2] *Hist. Comparée*, &c. Tome II. pp. 300, 301. See also the article *Fichte* in this *Encyclopædia*.

[3] *Hist. Comparée*, &c. Tome II. p. 314. The doctrine here ascribed to Fichte by Degerando, although its unparalleled absurdity might well excite some doubts about the correctness of the historian, is not altogether a novelty in the history of philosophy. It is in point of fact nothing more than a return to those gross conceptions of the mind in the infancy of human reason, which Mr Smith has so well described in the following passage:—"In the first ages of the world, the seeming incoherence of the appearances of nature so confounded mankind, that they despaired of discovering in her operations any regular system. . . . . . Their gods, though they were apprehended to interpose upon some particular occasions, were so far from being regarded as the creators of the world, that their origin was apprehended to be posterior to that of the world. The earth (according to Hesiod) was the first production of the chaos. The heavens arose out of the earth, and from both together, all the gods who afterwards inhabited them. Nor was this notion confined to the vulgar, and to those poets who seem to have recorded the vulgar theology. . . . . The same notion of the spontaneous origin of the world was embraced (as Aristotle tells us) by the early Pythagoreans. . . Mind, and understanding, and consequently Deity, being the most perfect, were necessarily, according to them, the last productions of nature. For, in all other things, what was most perfect, they observed, always came last: As in plants and animals, it is not the seed that is most perfect, but the complete animal, with all its members in the one; and the complete plant, with all its branches, leaves, flowers, and fruits, in the other."—(Smith's *Post. Essays on Philosophical Subjects*, pp. 106, 107.)

[4] *De l'Allemagne*. Tome III. p. 107. Londres, 1813.

as the source of all reality as well as of all science, and in thus transporting the mind into an intellectual region, inaccessible to men possessed only of the ordinary number of senses, both agree; and to this vein of transcendental mysticism may probably be ascribed the extraordinary enthusiasm with which their doctrines appear to have been received by the German youth. Since the time when Degerando wrote, a new and very unexpected revolution is said to have taken place among Schelling's disciples; many of them, originally educated in the Protestant faith, having thrown themselves into the bosom of the Catholic church[1]......" The union of the faithful of this school forms an invisible church, which has adopted for its symbol and watchword, the Virgin Mary; and hence rosaries are sometimes to be seen in the hands of those who reckon Spinoza among the greatest prophets." It is added, however, with respect to this invisible church, that " its members have embraced the Catholic religion, not as the *true* religion, but as the most *poetical;*" a thing not improbable among a people who have so strong a disposition to mingle together poetry and metaphysics in the same compositions.[2] But it is painful to contemplate these sad aberrations of human reason; nor would I have dwelt on them so long as I have done, had I not been anxious to convey to my readers a general, but I trust not unfaithful, idea of the style and spirit of a philosophy, which, within the short period of our recollection, rose, flourished, and fell; and which, in every stage of its history, furnished employment to the talents of some of the most learned and able of our contemporaries.[3]

The space which I have allotted to Kant has so far exceeded what I intended he should occupy, that I must pass over the names of many of his countrymen much more worthy of public attention. In the account given by Degerando of the opponents of the Kantian system, some remarks are quoted from different writers, which convey a very favourable idea of the works from which they are borrowed. Among these I would more particularly distinguish those ascribed to Jacobi and to Reinhold. In the Memoirs, too, of the Berlin Academy, where, as Degerando justly observes, the philosophy of Locke found an asylum, while banished from the rest of Germany, there is a considerable number of metaphysical articles of the highest merit.[4] Nor must I omit to mention the contributions to this science by the university of Goettingen; more especially on questions connected with the philosophy of language. I have great pleasure, also, in acknowledging the entertainment I have received, and the lights I have borrowed from the learned labours of Meiners and of Herder; but none of these are so closely connected with the history of metaphysics as to justify me in entering into particular details with respect to them. I am ashamed to say that, in Great Britain, the only one of these names which has been much talked of is that of Kant; a circumstance which, I trust, will apologise for the length to which the foregoing observations have extended.[5]

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[1] See a paper by M. G. Schweighauser in the London *Monthly Magazine* for 1804, p. 207.

[2] " Aussi les Allemands mèlent ils trop souvent la Métaphysique à la Poésie."—*Allemagne*, Vol. III. p. 133. " Nothing (says Mr Hume) is more dangerous to reason than the flights of imagination, and nothing has been the occasion of more mistakes among philosophers. Men of bright fancies may, in this respect, be compared to those angels, whom the scripture represents as covering their eyes with their wings."—(*Treatise of Human Nature*, Vol. I. p. 464.)

[3] According to a French writer, who appears to have resided many years in Germany, and who has enlivened a short Essay on the *Elements of Philosophy* with many curious historical details concerning Kant and his successors, both Fichte and Schelling owed much of their reputation to the uncommon eloquence displayed in their academical lectures:—" Cette doctrine sortait de la bouche de Fichte, revêtu de ces ornemens qui donnent la jeunesse, la beauté, et la force au discours. On ne se lassait point en l'écoutant."

Of Schelling he expresses himself thus:—" Schelling, appelé à l'universite de Wirzbourg, y attira par sa reputation un concours nombreux d'auditeurs, qu'il enchainait à ses leçons par la richesse de sa diction et par l'etendue de ses connoissances. De là, il est venu à Munich, où je le revis en 1813. On dit qu'il a embrassé la religion Catholique."—(*Essai sur les Elémens de la Philosophie*, par G. GLEY, Principal au College d'Alençon. Paris, 1817. pp. 152, 138.)

[4] In a volume of this collection (for the year 1797), which happens to be now lying before me, there are three profound and important *Memoirs* on *Probabilities*, by M. Prevost and M. l'Huillier. Neither of these authors, I am aware, is of German origin, but as the Academy of Berlin has had the merit to bring their papers before the public, I could not omit this opportunity of recommending them to the attention of my readers. To a very important observation made by MM. Prevost and l'Huillier, which has been the subject of some dispute, I am happy to avail myself of the same opportunity to express my unqualified assent.—(See pp. 15. and 31. of the memoirs belonging to the *Classe de Philosophie Spéculative.*)

[5] See Note A A A.

The only other country of Europe from which any contributions to metaphysical philosophy could be reasonably looked for, during the eighteenth century, is Italy; and to this particular branch of science I do not know that any Italian of much celebrity has, in these later times, turned his attention. The metaphysical works of Cardinal Gerdil (a native of Savoy) are extolled by some French writers; but none of them have ever happened to fall in my way.[1] At a more recent period, Genovesi, a Neapolitan philosopher[2] (best known as a political economist), has attracted a good deal of notice by some metaphysical publications. Their chief object is said to be to reconcile, as far as possible, the opinions of Leibnitz with those of Locke. "Pendant que Condillac donnait inutilement des leçons à un Prince d'Italie, Genovesi en donnait avec plus de succès à ses élèves Napolitains: il combinait le mieux qu'il lui etoit possible les théories de Leibnitz, pour lequel il eut toujours une prevention favorable, avec celle de Locke, qu'il accrédita le premier en Italie."[3] Various other works of greater or less celebrity, from Italian authors, seem to announce a growing taste in that part of Europe for these abstract researches. The names of Francisco Soave, of Biagioli, and of Mariano Gigli, are advantageously mentioned by their countrymen; but none of their works, as far as I can learn, have yet reached Scotland. Indeed, with the single exception of Boscovich, I recollect no writer on the other side of the Alps, whose metaphysical speculations have been heard of in this island. This is the more to be regretted, as the specimens he has given, both of originality and soundness in some of his abstract discussions, convey a very favourable idea of the schools in which he received his education. The authority to which he seems most inclined to lean is that of Leibnitz; but, on all important questions he exercises his own judgment, and often combats Leibnitz with equal freedom and success. Remarkable instances of this occur in his strictures on the principle of the *sufficient reason*, and in the limitations with which he has admitted the *law of continuity*.

The vigour, and, at the same time, the versatility of talents, displayed in the voluminous works of this extraordinary man, reflect the highest honour on the country which gave him birth, and would almost tempt one to give credit to the theory which ascribes to the genial climates of the south a beneficial influence on the intellectual frame. Italy is certainly the only part of Europe where mathematicians and metaphysicians of the highest rank have produced such poetry as has proceeded from the pens of Boscovich and Stay. It is in this rare balance of imagination, and of the reasoning powers, that the perfection of the human intellect will be allowed to consist; and of this balance a far greater number of instances may be quoted from Italy (reckoning from Galileo[1] downwards), than in any other corner of the learned world.

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[1] His two first publications, which were directed against the philosophy of Locke (if we may judge from their titles), are not likely, in the present times, to excite any curiosity. 1. *The Immateriality of the Soul Demonstrated against Mr Locke, on the same Principles on which this Philosopher has Demonstrated the Existence and the Immateriality of God.* Turin, 1747. 2. *Defence of the Opinion of Malebranche, on the Nature and Origin of our Ideas, against the examination of Mr Locke.* Turin, 1748. The only other works of Gerdil which I have seen referred to are, *A Dissertation on the Incompatibility of the Principles of Descartes with those of Spinoza*; and *A Refutation of some Principles maintained in the Emile of Rousseau.*

Of this last performance, Rousseau is reported to have said, "*Voila l'unique écrit publié contre moi que j'ai trouvé digne d'être lu en entier.*" (*Nouveau Dict. Hist.* article *Gerdil.*) In the same article, a reference is made to a public discourse of the celebrated M. Mairan, of the Academy of Sciences, in which he pronounces the following judgment on Gerdil's metaphysical powers: "*Gerdil porte avec lui dans tous ces discours un esprit géométrique, qui manque trop souvent aux géomètres mémes.*"

[2] Born 1712, died 1769.

[3] *Revue Encyclopédique, ou Analyse Raisonnée des Productions les plus Remarquables dans la Littérature, les Sciences, et les Arts.* I Vol. 3me livraison, p. 515. Paris, Mars 1819. (The writer of the article quoted in the text is M. Sarpi, an Italian by birth, who, after having distinguished himself by various publications in his own country, has now (if I am not mistaken) fixed his residence at Paris. In his own philosophical opinions, he seems to be a follower of Condillac's school, otherwise he would scarcely have spoken so highly as he has done of the French Ideologists: "L'Idéologie qui, d'apres sa dénomination récente pourrait être considerée comme specialement due aux Français, mais qui est aussi ancienne que la philosophie, puisqu'elle a pour objet la génération des idées et l'analyse des facultés qui concourent à leur formation, n'est pas étrangère aux Italiens, comme on pourrait le croire.")

Genovesi is considered, by an historian of high reputation, as the reformer of Italian philosophy. If the execution of his *Treatise on Logic* corresponds at all to the enlightened views with which the design seems to have been conceived, it cannot fail to be a work of much practical utility. "Ma chi può veramente dirsi il riformatore dell' Italiana filosofia, chi la fece tosto conoscere, e respettare da' pùi dotti filosofi delle altre nazioni, chi seppe arricchire di nuovi pregi la logica, la metafisica, e la morale, fu il celebre Genovesi. Tuttochè molti fossero stati i filosofi che cercarono con sottili riflessioni, e giusti precetti d'ajutare la mente a pensare ed a ragionare con esattezza e verità, e Bacone, Malebranche, Loke, Wolfio, e molt' altri sembrassero avere esaurito quanto v'era da scrivere su tale arte, seppe nondimeno il Genovesi trovare nuove osservazioni, e nuovi avvertimenti da preporre, e dare una logica piu piena e compiuta, e piu utile non solo allo studio della filosofia, e generalmente ad ogni studio scientifico, ma eziandío alla condotta morale, ed alla civile società."—(*Dell' Origine, de Progressi, e dello Stato attuale d'Ogni Letteratura* dell' Abate D. GIOVANNI ANDRES. Tomo XV. pp. 260. 261. Venezia, 1800.)

The sciences of ethics, and of political economy, seem to be more suited to the taste of the modern Italians, than logic or metaphysics, properly so called. And in the two former branches of knowledge, they have certainly contributed much to the instruction and improvement of the eighteenth century. But on these subjects we are not yet prepared to enter.

In the New World, the state of society and of manners has not hitherto been so favourable to abstract science as to pursuits which come home directly to the business of human life. There is, however, *one* metaphysician of whom America has to boast, who, in logical acuteness and subtility, does not yield to any disputant bred in the universities of Europe. I need not say, that I allude to Jonathan Edwards. But, at the time when he wrote, the state of America was more favourable than it now is, or can for a long period be expected to be, to such inquiries as those which engaged his attention; inquiries, by the way, to which his thoughts were evidently turned, less by the impulse of speculative curiosity, than by his anxiety to defend the theological system in which he had been educated, and to which he was most conscientiously and zealously attached. The effect of this anxiety in sharpening his faculties, and in keeping his polemical vigilance constantly *on the alert*, may be traced in every step of his argument.[2]

In the mean time, a new and unexpected mine of intellectual wealth has been opened to the learned of Europe, in those regions of the East, which, although in all probability the cradle of civilisation and science, were, till very lately, better known in the annals of commerce than of philosophy. The metaphysical and ethical remains of the Indian sages are, in a peculiar degree, interesting and instructive; inasmuch as they seem to have furnished the germs of the chief systems taught in the Grecian schools. The favourite theories, however, of the Hindoos will, all of them, be found, more or less, tinctured with those ascetic habits of abstract and mystical meditation which seem to have been, in all ages, congenial to their constitutional temperament. Of such habits, an Idealism, approaching to that of Berkeley and Malebranche, is as natural an offspring, as Materialism is of the gay and dissipated manners, which, in great and luxurious capitals, are constantly inviting the thoughts abroad.

To these remains of ancient science in the

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[1] See a most interesting account of Galileo's taste for poetry and polite literature in Ginguené, *Histoire Littéraire d'Italie*. Tome V. pp. 331, *et seq.* á Paris, 1812.

[2] While this *Dissertation* was in the press, I received a new American publication, entitled, "*Transactions of the Historical and Literary Committee of the American Philosophical Society, held at Philadelphia, for Promoting Useful Knowledge*," Vol. I. Philadelphia, 1819. From an advertisement prefixed to this volume, it appears that, at a meeting of this learned body in 1815, it was resolved, "That a new committee be added to those already established, to be denominated the Committee of History, Moral Science, and General Literature." It was with great pleasure I observed, that one of the first objects to which the committee has directed its attention is to investigate and ascertain, as much as possible, the structure and grammatical forms of the languages of the aboriginal nations of America. The *Report* of the corresponding secretary (M. Duponceau), dated January 1819, with respect to the progress then made in this investigation, is highly curious and interesting, and displays not only enlarged and philosophical views, but an intimate acquaintance with the philological researches of Adelung, Vater, Humboldt, and other German scholars. All this evinces an enlightened curiosity, and an extent of literary information, which could scarcely have been expected in these rising states for many years to come.

The rapid progress which the Americans have lately made in the art of writing has been remarked by various critics, and it is certainly a very important fact in the history of their literature. Their state papers were, indeed, always distinguished by a strain of animated and vigorous eloquence; but as most of them were composed on the spur of the occasion, their authors had little time to bestow on the niceties, or even upon the purity of diction. An attention to these is the slow offspring of learned leisure, and of the diligent study of the best models. This I presume was Gray's meaning, when he said, that "good writing not only required great parts, but the very best of those parts;"*—a maxim which, if true, would point out the state of the public taste with respect to style, as the surest test among any people of the general improvement which their intellectual powers have received; and which, when applied to our Trans-atlantic brethren, would justify sanguine expectations of the attainments of the rising generation.

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* Note of Mason on a Letter of Gray's to Dr Wharton, on the death of Dr Middleton.

East, the attention of Europe was first called by Bernier, a most intelligent and authentic traveller, of whom I formerly took notice as a favourite pupil of Gassendi. But it is chiefly by our own countrymen that the field which he opened has been subsequently explored; and of their meritorious labours in the prosecution of this task, during the reign of our late Sovereign, it is scarcely possible to form too high an estimate.

Much more, however, may be yet expected, if such a prodigy as Sir William Jones should again appear, uniting, in as miraculous a degree, the gift of tongues with the spirit of philosophy. The structure of the Sanscrit, in itself, independently of the treasures locked up in it, affords one of the most puzzling subjects of inquiry that was ever presented to human ingenuity. The affinities and filiations of different tongues, as evinced in their corresponding roots and other coincidences, are abundantly curious, but incomparably more easy in the explanation, than the systematical analogy which is said to exist between the Sanscrit and the Greek (and also between the Sanscrit and the Latin, which is considered as the most ancient dialect of the Greek), in the conjugations and flexions of their verbs, and in many other particulars of their mechanism; an analogy which is represented as so complete, that, in the versions which have been made from the one language into the other, "Sanscrit," we are told, "answers to Greek, as face to face in a glass."[1] That the Sanscrit did not grow up to the perfection which it now exhibits, from popular and casual modes of speech, the unexampled regularity of its forms seems almost to demonstrate; and yet, should this supposition be rejected, to what other hypothesis shall we have recourse, which does not involve equal, if not greater improbabilities? The problem is well worthy of the attention of philosophical grammarians; and the solution of it, whatever it may be, can scarcely fail to throw some new lights on the history of the human race, as well as on that of the human mind.

SECTION VIII.

Metaphysical Philosophy of Scotland.

It now only remains for me to take a slight survey of the rise and progress of the Metaphysical Philosophy of Scotland; and if, in treating of this, I should be somewhat more minute than in the former parts of this Historical Sketch, I flatter myself that allowances will be made for my anxiety to supply some chasms in the literary history of my country, which could not be so easily, nor perhaps so authentically, filled up by a younger hand.

The Metaphysical Philosophy of Scotland, and, indeed, the literary taste in general, which so remarkably distinguished this country during the last century, may be dated from the lectures of Dr Francis Hutcheson, in the University of Glasgow. Strong indications of the same speculative spirit may be traced in earlier writers;[2] but it was from this period that Scotland, after a long slumber, began again to attract general notice in the republic of letters.[3]

The writings of Dr Hutcheson, however, are more closely connected with the history of Ethical than of Metaphysical Science; and I shall, accordingly, delay any remarks which I have to offer upon them till I enter upon that part of my subject. There are, indeed, some very original and important metaphysical hints scattered over his works; but it is chiefly as an ethical writer that he is known to the world, and that he is entitled to a place among the philosophers of the eighteenth century.[1]

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[1] Letter from the Reverend David Brown, Provost of the College of Fort William, about the *Sanscrit Edition of the Gospels* (dated Calcutta, September 1806, and published in some of the *Literary Journals* of the day.)

[2] See Note B B B.

[3] An Italian writer of some note, in a work published in 1763, assigns the same date to the revival of letters in Scotland. ‘Fra i tanti, e si chiari Scrittori che fiorirono nella Gran Bretagna a’ tempi della Regina Anna, non se ne conta pur uno,

Among the contemporaries of Dr Hutcheson, there was one Scottish metaphysician (Andrew Baxter, author of the *Inquiry into the Nature of the Human Soul),* whose name it would be improper to pass over without some notice, after the splendid eulogy bestowed on his work by Warburton. "He who would see the justest and precisest notions of God and the soul may read this book, one of the most finished of the kind, in my humble opinion, that the present times, greatly advanced in true philosophy, have produced"[2]

To this unqualified praise, I must confess, I do not think Baxter's *Inquiry* altogether entitled, although I readily acknowledge that it displays considerable ingenuity, as well as learning. Some of the remarks on Berkeley's argument against the existence of matter are acute and just, and, at the time when they were published, had the merit of novelty.

One of his distinguishing doctrines is, that the Deity is the *immediate* agent in producing the phenomena of the *Material World;* but that, in the *Moral World,* the case is different,—a doctrine which, whatever may be thought of it in other respects, is undoubtedly a great improvement on that of Malebranche, which, by representing God as the only agent in the universe, was not less inconsistent than the scheme of Spinoza with the moral nature of Man. "The Deity (says Baxter) is not only at the head of Nature, but in every part of it. A chain of material causes betwixt the Deity and the effect produced, and much more a series of them, is such a supposition as would conceal the Deity from the knowledge of mortals for ever. We might search for matter above matter, till we were lost in a labyrinth out of which no philosopher ever yet found his way.—This way of bringing in second causes is borrowed from the government of the moral world, where free agents act a part; but it is very improperly ap-

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che sia uscito di Scozia. . . . . .Francesco Hutcheson venuto in Iscozia, a professarvi la Filosofia, e gli studii di umanità, nella Universita di Glasgow, v'insinuò per tutto il paese colle istruzione a viva voce, e con egregie opere date alle stampe, un vivo genio per gli studii filosofici, e literarii, e sparse quì fecondissimi semi, d'onde vediamo nascere sì felice frutti, e sì copiose."—*(Discorso sopra le Vicende della Litteratura, del* Sig. CARLO DENINA, p. 224, Glasgow edit. 1763.)

I was somewhat surprised to meet with the foregoing observations in the work of a foreigner; but, wherever he acquired his information, it evinces, in those from whom it was derived, a more intimate acquaintance with the traditionary history of letters in this country than has fallen to the share of most of our own authors who have treated of that subject. I have heard it conjectured, that the materials of his section on Scottish literature had been communicated to him by Mr Hume.

Another foreign writer, much better qualified than Denina to appreciate the merits of Hutcheson, has expressed himself upon this subject with his usual precision. "L'ecole Ecossaise a en quelque sorte pour fondateur Hutcheson, maître et prédécesseur de Smith. C'est ce philosophe qui lui a imprimé son caractère, et qui a commencé à lui donner de l'eclat." In a note upon this passage, the author observes,—"C'est en ce seul sens qu'on peut donner un chef à une école de philosophie qui, comme on le verra, professe d'ailleurs la plus parfaite indépendance de l'autorité.—(See the excellent reflections upon the posthumous works of Adam Smith, annexed by M. Prevost to his translation of that work.)

Dr Hutcheson's first course of lectures at Glasgow was given in 1730. He was a native of Ireland, and is accordingly called by Denina "un dotto Irlandese;" but he was of Scotch extraction (his father or grandfather having been a younger son of a respectable family in Ayrshire), and he was sent over when very young to receive his education in Scotland.

[1] One of the chief objects of Hutcheson's writings was to oppose the licentious system of Mandeville; a system which was the natural offspring of some of Locke's reasonings against the existence of innate practical principles.

As a moralist, Hutcheson was a warm admirer of the ancients, and seems to have been particularly smitten with that favourite doctrine of the Socratic school which identifies the *good* with the *beautiful.* Hence he was led to follow much too closely the example of Shaftesbury, in considering moral distinctions as founded more on sentiment than on reason, and to speak vaguely of virtue as a sort of *noble enthusiasm;* but he was led, at the same time, to connect with his ethical speculations some collateral inquiries concerning Beauty and Harmony, in which he pursued, with considerable success, the path recently struck out by Addison in his *Essays on the Pleasures of the Imagination.* These inquiries of Hutcheson, together with his *Thoughts on Laughter*, although they may not be very highly prized for their depth, bear everywhere the marks of an enlarged and cultivated mind, and, whatever may have been their effects elsewhere, certainly contributed powerfully, in our Northern seats of learning, to introduce a taste for more liberal and elegant pursuits than could have been expected so soon to succeed to the intolerance, bigotry, and barbarism of the preceding century.

[2] See WARBURTON'S *Divine Legation of Moses demonstrated*, p. 395 of the first edition.

plied to the material universe, where matter and motion only (or mechanism, as it is called) comes in competition with the Deity."[1]

Notwithstanding, however, these and other merits, Baxter has contributed so little to the advancement of that philosophy which has since been cultivated in Scotland, that I am afraid the very slight notice I have now taken of him may be considered as an unseasonable digression. The great object of his studies plainly was, to strengthen the old argument for the soul's immateriality, by the new lights furnished by Newton's discoveries. To the intellectual and moral phenomena of Man, and to the laws by which they are regulated, he seems to have paid but little attention.[2]

While Dr Hutcheson's reputation as an author, and still more as an eloquent teacher, was at its zenith in Scotland, Mr Hume began his literary career, by the publication of his *Treatise of Human Nature.* It appeared in 1739, but seems at that time to have attracted little or no attention from the public. According to the author himself, "never literary attempt was more unfortunate. It fell dead-born from the press, without reaching such distinction as even to excite a murmur among the zealots." It forms, however, a very important link in this Historical Sketch, as it has contributed, either directly or indirectly, more than any other single work, to the subsequent progress of the Philosophy of the Human Mind. In order to adapt his principles better to the public taste, the author afterwards threw them into the more popular form of Essays; but it is in the original work that philosophical readers will always study his system, and it is there alone that the relations and bearings of its different parts, as well as its connection with the speculations of his immediate predecessors, can be distinctly traced. It is there, too, that his metaphysical talents appear, in my opinion, to the greatest advantage; nor am I certain that he has anywhere else displayed more skill or a sounder taste in point of composition.[3]

The great objects of Mr Hume's *Treatise of*

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[1] Appendix to the first part of the *Inquiry into the Nature of the Human Soul*, pp. 109, 110.

[2] Baxter was born at Old Aberdeen, in 1686 or 1687, and died at Whittingham, in East Lothian, in 1750. I have not been able to discover the date of the first edition of his *Inquiry into the Nature of the Human Soul*, but the second edition appeared in 1737, two years before the publication of Mr Hume's *Treatise of Human Nature.*

[3] A gentleman, who lived in habits of great intimacy with Dr Reid towards the close of his life, and on whose accuracy I can fully depend, remembers to have heard him say repeatedly, that "Mr Hume, in his *Essays*, appeared to have *forgotten his Metaphysics.*" Nor will this supposition be thought improbable, if, in addition to the subtle and fugitive nature of the subjects canvassed in the *Treatise of Human Nature*, it be considered that long before the publication of his *Essays*, Mr Hume had abandoned all his metaphysical researches. In proof of this, I shall quote a passage from a letter of his to Sir Gilbert Elliot, which, though without a date, seems from its contents to have been written about 1750 or 1751. The passage is interesting on another account, as it serves to show how much Mr Hume undervalued the utility of mathematical learning, and consequently how little he was aware of its importance, as an organ of physical discovery, and as the foundation of some of the most necessary arts of civilised life. "I am sorry that our correspondence should lead us into these abstract speculations. I have thought, and read, and composed very little on such questions of late. Morals, politics, and literature, have employed all my time; but still the other topics I must think more curious, important, entertaining, and useful, than any geometry that is deeper than Euclid."

I have said that it is in Mr Hume's earliest work that his metaphysical talents appear, in my opinion, to the greatest advantage. From the following advertisement, however, prefixed, in the latest editions of his works, to the second volume of his *Essays* and *Treatises*, Mr Hume himself would appear to have thought differently. "Most of the principles and reasonings contained in this volume were published in a work in three volumes, called *A Treatise of Human Nature;* a work which the author had projected before he left College, and which he wrote and published not long after. But not finding it successful, he was sensible of his error in going to the press too early, and he cast the whole anew in the following pieces, where some negligencies in his former reasoning, and some in the expression, are, he hopes, corrected. Yet several writers, who have honoured the author's philosophy with answers, have taken care to direct all their batteries against that juvenile work, which the author never acknowledged, and have affected to triumph in any advantage which they imagined they had obtained over it; a practice very contrary to all rules of candour and fair dealing, and a strong instance of those polemical artifices which a bigoted zeal thinks itself authorised to employ. Henceforth, the author desires, that the following pieces may alone be regarded as containing his philosophical sentiments and principles."

After this declaration, it certainly would be highly uncandid to impute to Mr Hume any philosophical sentiments or principles not to be found in his *Philosophical Essays*, as well as in his *Treatise.* But where is the unfairness of replying to any plausible arguments in the latter work, even although Mr Hume may have omitted them in his subsequent publications; more especially where these arguments supply any useful lights for illustrating his more popular compositions? The *Treatise of Human Nature* will certainly be remembered as long as any of Mr Hume's philosophical writings; nor is any person qualified either to approve or to reject his doctrines, who has not studied them in the systematical form in which they were originally cast. That Mr Hume's remonstrance may be just with respect to some of his adversaries, I believe to be true; but it is surely expressed in a tone more querulous and peevish than is justified by the occasion.

I shall take this opportunity of preserving another judgment of Mr Hume's (still more fully stated) on the merits of this

Human Nature will be best explained in his own words.

“ ’Tis evident that all the sciences have a relation, greater or less, to human nature, and that, however wide any of them may seem to run from it, they still return back by one passage or another. Even Mathematics, Natural Philosophy, and Natural Religion, are in some measure dependent on the science of Man, since they lie under the cognisance of men, and are judged of by their powers and faculties.......... If, therefore, the sciences of Mathematics, Natural Philosophy, and Natural Religion, have such a dependence on the knowledge of man, what may be expected in the other sciences, whose connection with human nature is more close and intimate? The sole end of logic is to explain the principles and operations of our reasoning faculty, and the nature of our ideas: Morals and criticism regard our tastes and sentiments, and politics consider men as united in society, and dependent on each other........... Here, then, is the only expedient from which we can hope for success in our philosophical researches, to leave the tedious lingering method which we have hitherto followed, and, instead of taking now and then a castle or village on the frontier, to march up directly to the capital or centre of these sciences, to human nature itself; which, being once masters of, we may everywhere else hope for an easy victory. From this station we may extend our conquests over all those sciences which more intimately concern human life, and may afterwards proceed at leisure to discover more fully those which are the objects of pure curiosity. There is no question of importance whose decision is not comprised in the Science of Man, and there is none which can be decided with any certainty before we become acquainted with that science. In pretending, therefore, to explain the principles of Human Nature, we, in effect, propose a complete system of the sciences, built on a foundation almost entirely new, and the only one upon which they can stand with any security.

“ And, as the science of man is the only solid foundation for the other sciences, so the only solid foundation we can give to this science itself must be laid on experience and observation. ’Tis no astonishing reflection to consider, that the application of experimental philosophy to moral subjects should come after that to natural, at the distance of above a whole century; since we find, in fact, that there was about the same interval betwixt the origin of these sciences; and that, reckoning from Thales to Socrates, the space of time is nearly equal to that betwixt my Lord Bacon and some late philosophers in England,[1] who have begun to put the science of man on a new footing, and have engaged the attention, and excited the curiosity of the public.”

I am far from thinking, that the execution of Mr Hume’s work corresponded with the magnificent design sketched out in these observations; nor does it appear to me that he had formed to himself a very correct idea of the manner in which the experimental mode of reasoning ought to be applied to moral subjects. He had, however, very great merit in separating entirely his speculations concerning the philosophy of the mind from all physiological hypotheses about the nature of the union between soul and body; and although, from some of his casual expressions, it may be suspected that he conceived our intellectual operations to result from bodily organisation,[2] he had yet much too large a share of good sense and sagacity to suppose, that, by study-

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juvenile work. I copy it from a private letter written by himself to Sir Gilbert Elliot, soon after the publication of his *Philosophical Essays*.

“ I believe the *Philosophical Essays* contain every thing of consequence relating to the Understanding, which you would meet with in the *Treatise;* and I give you my advice against reading the latter. By shortening and simplifying the questions, I really render them more complete. *Addo dum minuo.* The philosophical principles are the same in both; but I was carried away by the heat of youth and invention to publish too precipitately. So vast an undertaking, planned before I was one and twenty, and composed before twenty-five, must necessarily be very defective. I have repented my haste a hundred and a hundred times.”

[1] “ Mr Locke, Lord Shaftesbury, Dr Mandeville, Mr Hutcheson, Dr Butler,” &c.

[2] The only expression in his works I can recollect at present, that can give any reasonable countenance to such a suspicion, occurs in his *Posthumous Dialogues*, where he speaks of “ that little agitation of the brain which we call thought.”—(2d Edition, pp. 60, 61.) But no fair inference can be drawn from this, as the expression is put into the mouth of Philo the Sceptic; whereas the author intimates that Cleanthes speaks his own sentiments.

ing the latter, it is possible for human ingenuity to throw any light upon the former. His works, accordingly, are perfectly free from those gratuitous and wild conjectures, which a few years afterwards were given to the world with so much confidence by Hartley and Bonnet. And in this respect his example has been of infinite use to his successors in this northern part of the island. Many absurd theories have, indeed, at different times been produced by our countrymen; but I know of no part of Europe where such systems as those of Hartley and Bonnet have been so uniformly treated with the contempt they deserve as in Scotland.[1]

Nor was it in this respect alone, that Mr Hume's juvenile speculations contributed to forward the progress of our national literature. Among the many very exceptionable doctrines involved in them, there are various discussions, equally refined and solid, in which he has happily exemplified the application of metaphysical analysis to questions connected with taste, with the philosophy of jurisprudence, and with the theory of government. Of these discussions some afterwards appeared in a more popular form in his philosophical and literary Essays, and still retain a place in the latest editions of his works; but others, not less curious, have been suppressed by the author, probably from an idea, that they were too abstruse to interest the curiosity of ordinary readers. In some of these practical applications of metaphysical principles, we may perceive the germs of several inquiries which have since been successfully prosecuted by Mr Hume's countrymen; and, among others, of those which gave birth to Lord Kames's *Historical Law Tracts*, and to his *Elements of Criticism.*

The publication of Mr Hume's *Treatise* was attended with another important effect in Scotland. He had cultivated the art of writing with much greater success than any of his predecessors, and had formed his taste on the best models of English composition. The influence of his example appears to have been great and general; and was in no instance more remarkable than in the style of his principal antagonists, all of whom, in studying his system, have caught, in no inconsiderable degree, the purity, polish, and precision of his diction. Nobody, I believe, will deny, that Locke himself, considered as an English writer, is far surpassed, not only by Hume, but by Reid, Campbell, Gerard, and Beattie; and of this fact it will not be easy to find a more satisfactory explanation, than in the critical eye with which they were led to canvass a work, equally distinguished by the depth of its reasonings, and by the attractive form in which they are exhibited.

The fundamental principles from which Mr Hume sets out, differ more in words than in substance from those of his immediate predecessors. According to him, all the objects of our knowledge are divided into two classes, *impressions* and *ideas:* the former, comprehending our *sensations,* properly so called, and also our *perceptions* of sensible qualities (two things betwixt which Mr Hume's system does not lead him to make any distinction); the latter, the objects of our thoughts when we *remember* or *imagine,* or in general exercise any of our intellectual powers on things which are past, absent, or future. These ideas he considers as *copies* of our *impressions,* and the words which denote them as the only *signs* entitled to the attention of a philosopher; every word professing to denote an idea, of which the corresponding impressions cannot be pointed out, being *ipso facto* unmeaning and illusory. The obvious result of these principles is, that what Mr Hume calls *impressions,* furnish, either immediately or mediately, the whole materials about which our thoughts can be employed; a conclusion coinciding exactly with the account of the origin of our ideas borrowed by Gassendi from the ancient Epicureans.

With this fundamental principle of the Gassendists, Mr Hume combined the logical method recommended by their great antagonists the Cartesians, and (what seemed still more remote from his Epicurean starting ground) a strong leaning to the idealism of Malebranche and of

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[1] In no part of Mr Hume's metaphysical writings is there the slightest reference to either of these systems, although he survived the date of their publication little less than thirty years.

Berkeley. Like Descartes, he began with doubting of every thing, but he was too quick-sighted to be satisfied, like Descartes, with the solutions given by that philosopher of his doubts. On the contrary, he exposes the futility not only of the solutions proposed by Descartes himself, but of those suggested by Locke and others among his successors; ending at last where Descartes began, in considering no one proposition as more certain, or even as more probable than another. That the proofs alleged by Descartes of the existence of the material world are quite inconclusive, had been already remarked by many. Nay, it had been shown by Berkeley and others, that if the principles be admitted on which Descartes, in common with all philosophers, from Aristotle downwards, proceeded, the existence of the material world is impossible. A few bold thinkers, distinguished by the name of Egoists, had gone still farther than this, and had pushed their scepticism to such a length, as to doubt of everything but their own existence. According to *these*, the proposition, *cogito, ergo sum*, is the only truth which can be regarded as absolutely certain. It was reserved for Mr Hume to call in question even this proposition, and to admit only the existence of *impressions* and *ideas*. To dispute against the existence of these he conceived to be impossible, inasmuch as they are the immediate subjects of consciousness. But to admit the existence of the thinking and percipient *I*, was to admit the existence of that imaginary substance called *Mind*, which (according to him) is no more an object of human knowledge, than the imaginary and exploded substance called *Matter*.

From what has been already said, it may be seen, that we are not to look in Mr Hume's *Treatise* for any regular or connected system. It is neither a scheme of Materialism, nor a scheme of Spiritualism; for his reasonings strike equally at the root of both these theories. His aim is to establish a universal scepticism, and to produce in the reader a complete distrust in his own faculties. For this purpose he avails himself of the data assumed by the most opposite sects, shifting his ground skilfully from one position to another, as best suits the scope of his present argument. With the single exception of Bayle, he has carried this sceptical mode of reasoning farther than any other modern philosopher. Cicero, who himself belonged nominally to the same school, seems to have thought, that the controversial habits imposed on the Academical sect by their profession of universal doubt, required a greater versatility of talent and fertility of invention, than were necessary for defending any particular system of tenets;[1] and it is not improbable, that Mr Hume, in the pride of youthful genius, was misled by this specious but very fallacious idea. On the other hand, Bayle has the candour to acknowledge, that nothing is so easy as to dispute after the manner of the sceptics;[2] and to this proposition every man of reflection will find himself more and more disposed to assent, as he advances in life. It is experience alone that can convince us, how much more difficult it is to make any real progress in the search after truth, than to acquire a talent for plausible disputation.[3]

That this spirit of sceptical argument has been carried to a most pernicious excess in modern Europe, as well as among the ancient Academics, will, I presume, be now very generally allowed; but in the form in which it appears in Mr Hume's *Treatise*, its mischievous tendency has been more than compensated by the importance of those results for which it has prepared the way. The principles which he assumes were sanctioned in common by Gassendi, by Descartes, and by Locke; and from these, in most instances, he reasons with great logical accuracy and force. The conclusions to which he is thus led are often so extravagant and dangerous, that he ought to have regarded them as a proof of the unsoundness of his data; but if he had not the merit of drawing this inference himself, he at least forced it so irresistibly on the observation of his successors, as to be entitled to share with them in the honour of their discoveries. Perhaps, indeed, it may be questioned if the errors which he adopted from his predecessors would not have kept their ground till this day, had not his sagacity displayed so clearly the consequences which they necessarily involve. It is in this sense that we must understand a compliment paid to him by the ablest of his adversaries, when he says, that "Mr Hume's premises often do more than atone for his conclusions."[1]

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[1] "Nam si singulas disciplinas percipere magnum est, quanto majus omnes? quod facere iis necesse est, quibus propositum est, veri reperiendi causa, et contra omnes philosophos et pro omnibus dicere.—Cujus rei tantæ tamque difficilis facultatem consecutum esse me non profiteor: Secutum esse præ me fero."—(CICERO *De Nat. Deor.* l. i. v.)

[2] See the passage quoted from BAYLE, in page 86 of this *Dissertation.*

[3] In the very interesting account, given by Dr Holland, of Velara, a modern Greek physician, whom he met with at Larissa in Thessaly, a few slight particulars are mentioned, which let us completely into the character of that ingenious person. "It appeared," says Dr Holland, "that Velara had thought much on the various topics of Metaphysics and Morals, and his conversation on these topics bore the same tone of satirical scepticism which was apparent as the general feature of his opinions. We spoke of the questions of Materialism and Necessity, on both of which he declared an affirmative opinion."—(HOLLAND's *Travels in the Ionian Isles*, &c. p. 275.) "I passed this evening with Velara at his own house, and sat with him till a late hour. During part of the time our conversation turned upon metaphysical topics, and chiefly on the old Pyrrhonic doctrine of the non-existence of Matter. Velara, as usual, took the sceptical side of the argument, in which he showed much ingenuity and great knowledge of the more eminent controversialists on this and other collateral subjects."—(*Ibid.* p. 370.) We see here a lively picture of a character daily to be met with in more polished and learned societies, disputing not for truth but for victory; in the first conversation professing himself a Materialist; and in the second denying the existence of Matter; on both occasions, taking up that ground where he was most likely to provoke opposition. If any inference is to be drawn from the conversation of such an individual, with respect to his real creed, it is in favour of those

The bias of Mr Hume's mind to scepticism seems to have been much encouraged, and the success of his sceptical theories in the same proportion promoted, by the recent attempts of Descartes and his followers to demonstrate Self-evident Truths;—attempts which Mr Hume clearly perceived to involve, in every instance, that sort of paralogism which logicians call *reasoning in a circle.* The weakness of these pretended demonstrations is triumphantly exposed in the *Treatise of Human Nature;* and it is not very wonderful that the author, in the first enthusiasm of his victory over his immediate predecessors, should have fancied that the inconclusiveness of the proofs argued some unsoundness in the propositions which they were employed to support. It would, indeed, have done still greater honour to his sagacity if he had ascribed this to its true cause—the impossibility of confirming, by a process of reasoning, the *fundamental laws of human belief;* but (as Bacon remarks) it does not often happen to those who labour in the field of science, that the same person who sows the seed should reap the harvest.

From that strong sceptical bias which led this most acute reasoner, on many important questions, to shift his controversial ground according to the humour of the moment, *one* favourable consequence has resulted—that we are indebted to him for the most powerful antidotes we possess against some of the most poisonous errors of modern philosophy. I have already made a similar remark in speaking of the elaborate refutation of Spinozism by Bayle; but the argument stated by Hume, in his *Essay on the Idea of Necessary Connection* (though brought forward by the author with a very different view), forms a still more valuable accession to metaphysical science, as it lays the axe to the very root from which Spinozism springs. The cardinal principle on which the whole of that system turns is, that all events, physical and moral, are *necessarily* linked together as causes and effects; from which principle all the most alarming conclusions adopted by Spinoza follow as unavoidable and manifest corollaries. But, if it be true, as Mr Hume contends, and as most philosophers now admit, that physical causes and effects are known to us merely as *antecedents* and *consequents;* still more, if it be true that the word *necessity,* as employed in this discussion, is altogether unmeaning and insignificant, the whole system of Spinoza is nothing better than a rope of sand, and the very proposition which it pro-

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opinions which he controverts. These opinions, at least, we may confidently conclude to be agreeable to the general belief of the country where he lives.

[1] Mr Hume himself (to whom Dr Reid's *Inquiry* was communicated previous to its publication, by their common friend Dr Blair) seems not to have been dissatisfied with this apology for some of his speculations. "I shall only say (he observes in a letter addressed to the author), that if you have been able to clear up these abstruse and important subjects, instead of being mortified, I shall be so vain as to pretend to a share of the praise, and shall think that my errors, by having at least some coherence, had led you to make a more strict review of my principles, which were the common ones, and to perceive their futility."—(For the whole of Mr Hume's letter, see *Biographical Memoirs* of Smith, Robertson, and Reid, by the author of this Dissertation, p. 417.)

fesses to demonstrate is incomprehensible by our faculties. Mr Hume's doctrine, in the unqualified form in which he states it, may lead to other consequences not less dangerous: but, if he had not the good fortune to conduct metaphysicians to the truth, he may at least be allowed the merit of having shut up for ever one of the most frequented and fatal paths which led them astray.

In what I have now said, I have supposed my readers to possess that general acquaintance with Mr Hume's *Theory of Causation* which all well-educated persons may be presumed to have acquired. But the close connection of this part of his work with some of the historical details which are immediately to follow, makes it necessary for me, before I proceed farther, to recapitulate a little more particularly some of his most important conclusions.

It was, as far as I know, first shown in a satisfactory manner by Mr Hume, that "every demonstration which has been produced for the necessity of a cause to every new existence, is fallacious and sophistical."[1] In illustration of this assertion, he examines three different arguments which have been alleged as proofs of the proposition in question; the first by Mr Hobbes; the second by Dr Clarke; and the third by Mr Locke. And I think it will now be readily acknowledged by every competent judge, that his objections to all these pretended demonstrations are conclusive and unanswerable.

When Mr Hume, however, attempts to show that the proposition in question is not *intuitively* certain, his argument appears to me to amount to nothing more than a logical quibble. Of this one would almost imagine that he was not insensible himself, from the short and slight manner in which he hurries over the discussion. "All certainty (he observes) arises from the comparison of ideas, and from the discovery of such relations as are unalterable, so long as the ideas continue the same. These relations are *resemblance, proportions in quantity and number, degrees of any quality, and contrariety;* none of which are implied in this proposition, *whatever has a beginning has also a cause of existence.* That proposition, therefore, is not intuitively certain. At least, any one who would assert it to be intuitively certain, must deny these to be the only infallible relations, and must find some other relation of that kind to be implied in it, which it will be then time enough to examine."

Upon this passage, it is sufficient for me to observe, that the whole force of the reasoning hinges on two assumptions, which are not only gratuitous, but false. 1*st*, That all certainty arises from the comparison of ideas. 2*dly*, That *all* the unalterable relations among our ideas are comprehended in his own arbitrary enumeration; *Resemblance, proportions in quantity and number, degrees of any quality, and contrariety.* When the correctness of these two premises shall be fully established, it will be time enough (to borrow Mr Hume's own words) to examine the justness of his conclusion.

From this last reasoning, however, of Mr Hume, it may be suspected, that he was aware of the vulnerable point against which his adversaries were most likely to direct their attacks. From the weakness, too, of the entrenchments which he has here thrown up for his own security, he seems to have been sensible, that it was not capable of a long or vigorous resistance. In the mean time, he betrays no want of confidence in his original position; but repeating his assertion, that "we derive the opinion of the necessity of a cause to every new production, neither from demonstration nor from intuition," he boldly concludes, that "this opinion must necessarily arise from observation and experience."—(Vol. I. p. 147.) Or, as he elsewhere expresses himself, "All our reasonings concerning causes and effects are derived from nothing but custom; and, consequently, belief is more properly an act of the *sensitive* than of the *cogitative* part of our natures."—(*Ibid.* p. 321.)

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[1] *Treatise of Human Nature*, Vol. I. p. 144.—Although Mr Hume, however, succeeded better than any of his predecessors, in calling the attention of philosophers to this discussion, his opinion on the subject does not possess the merit, in point of originality, which was supposed to belong to it either by himself or by his antagonists. See the passages which I have quoted in proof of this, in the first volume of the *Philosophy of the Human Mind*, p. 542. *et seq.* fourth edit. and also in the second volume of the same work, p. 556. *et seq.* second edit. Among these, I request the attention of my readers more particularly to a passage from a book entitled, *The Procedure, Extent, and Limits of the Human Understanding*, published two years before the *Treatise of Human Nature*, and commonly ascribed to Dr Browne, Bishop of Cork. The coincidence is truly wonderful, as it can scarcely, by any possibility, be supposed that this book was ever heard of by Mr Hume.

The distinction here alluded to between the *sensitive* and the *cogitative* parts of our nature (it may be proper to remind my readers) makes a great figure in the works of Cudworth and of Kant. By the former it was avowedly borrowed from the philosophy of Plato. To the latter, it is not improbable, that it may have been suggested by this passage in Hume. Without disputing its justness or its importance, I may be permitted to express my doubts of the propriety of stating, so strongly as has frequently been done, the one of these parts of our nature in contrast with the other. Would it not be more philosophical, as well as more pleasing, to contemplate the beautiful harmony between them, and the gradual steps by which the mind is trained by the intimations of the former, for the deliberate conclusions of the latter? If, for example, our conviction of the permanence of the laws of nature be not founded on any process of reasoning (a proposition which Mr Hume seems to have established with demonstrative evidence), but be either the result of an instinctive principle of belief, or of the association of ideas, operating at a period when the light of reason has not yet dawned, what can be more delightful than to find this suggestion of our *sensitive frame*,[1] verified by every step which our reason afterwards makes in the study of physical science; and confirmed with mathematical accuracy by the never-failing accordance of the phenomena of the heavens with the previous calculations of astronomers! Does not this afford a satisfaction to the mind, similar to what it experiences, when we consider the adaptation of the instinct of suction, and of the organs of respiration, to the physical properties of the atmosphere? So far from encouraging scepticism, such a view of human nature seems peculiarly calculated to silence every doubt about the veracity of our faculties.[2]

It is not my business at present to inquire into the soundness of Mr Hume's doctrines on this subject. The rashness of some of them has, in my opinion, been sufficiently shown by more than one of his antagonists. I wish only to remark the important step which he made, in exposing the futility of the reasonings by which Hobbes, Clarke, and Locke, had attempted to demonstrate the metaphysical axiom, that "every thing which begins to exist must have a cause;" and the essential service which he rendered to true philosophy, by thus pointing out indirectly to his successors the only solid ground on which that principle is to be defended. It is to this argument of Hume's, according to Kant's own acknowledgment, that we owe the *Critique of Pure Reason;* and to this we are also indebted for the far more luminous refutations of scepticism by Mr Hume's own countrymen.

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[1] Upon either of these suppositions, Mr Hume would, with equal propriety, have referred our anticipation of the future event to the *sensitive part of our nature;* and, in point of fact, the one supposition would have answered his purpose as well as the other.

[2] It is but justice to Mr Hume to remark, that, in his later publications, he has himself suggested this very idea as the best solution he could give of his own doubts. The following passage, which appears to me to be eminently philosophical and beautiful, I beg leave to recommend to the particular attention of Kant's disciples:—

" Here, then, is a kind of pre-established harmony between the course of nature and the succession of our ideas; and though the powers and forces by which the former is governed be wholly unknown to us, yet our thoughts and conceptions have still, we find, gone on in the same train with the other works of nature. Custom is that principle by which this correspondence has been effected; so necessary to the subsistence of our species, and the regulation of our conduct in every circumstance and occurrence of human life. Had not the presence of an object instantly excited the idea of those objects commonly conjoined with it, all our knowledge must have been limited to the narrow sphere of our memory and senses; and we should never have been able to adjust means to ends, or employ our natural powers, either to the producing of good, or avoiding of evil. Those who delight in the discovery and contemplation of *final causes* have here ample subject to employ their wonder and admiration.

" I shall add, for a further confirmation of the foregoing theory, that, as this operation of the mind, by which we infer like effects from like causes, and *vice versa*, is so essential to the subsistence of all human creatures, it is not probable that it could be trusted to the fallacious deductions of our reason, which is slow in its operations, appears not in any degree during the first years of infancy, and at best is, in every age and period of human life, extremely liable to error and mistake. It is more conformable to the ORDINARY WISDOM OF NATURE to secure so necessary an act of the mind by some instinct or mechanical tendency which may be infallible in its operations, may discover itself at the first appearance of life and thought, and may be independent of all the laboured deductions of the understanding. As nature has taught us the use of our limbs, without giving us the knowledge of the muscles and nerves by which they are actuated, so has she implanted in us an instinct which carries forward the thoughts in a correspondent course to that which she has established among external objects; though we are ignorant of those powers and forces on which this regular course and succession of objects totally depends."—(See, in the last editions of Mr HUME's *Philosophical Essays*, published during his own lifetime, the two sections entitled *Sceptical Doubts concerning the Operations of the Understanding;* and *Sceptical Solution of these Doubts.* The title of the latter of these sections has, not altogether without reason, incurred the ridicule of Dr Beattie, who translates it, *Doubtful Solution of Doubtful Doubts.* But the essay contains much sound and important matter, and throws a strong light on some of the chief difficulties which Mr Hume himself had started. Sufficient justice has not been done to it by his antagonists.)

In the course of Mr Hume's very refined discussions on this subject, he is led to apply them to one of the most important principles of the mind,—our belief of the continuance of the laws of nature; or, in other words, our belief that the future course of nature will resemble the past. And here, too (as I already hinted), it is very generally admitted, that he has succeeded completely in overturning all the theories which profess to account for this belief, by resolving it into a process of reasoning.[1] The only difference which seems to remain among philosophers is, whether it can be explained, as Mr Hume imagined, by means of the association of ideas; or, whether it must be considered as an original and fundamental law of the human understanding;—a question, undoubtedly abundantly curious, as a problem connected with the *Theory of the Mind;* but to which more practical importance has sometimes been attached than I conceive to be necessary.[2]

That Mr Hume himself conceived his refutation of the theories which profess to assign *a reason* for our faith in the permanence of the laws of nature, to be closely connected with his sceptical conclusions concerning *causation,* is quite evident from the general strain of his argument; and it is, therefore, not surprising that this refutation should have been looked on with a suspicious eye by his antagonists. Dr Reid was, I believe, the first of these who had the sagacity to perceive, not only that it is strictly and incontrovertibly logical, but that it may be safely admitted, without any injury to the doctrines which it was brought forward to subvert.

Another of Mr Hume's attacks on these doctrines was still bolder and more direct. In conducting it he took his vantage ground from his own account of the origin of our ideas. In this way he was led to expunge from his Philosophical Vocabulary every word of which the meaning cannot be explained by a reference to the *impression* from which the corresponding *idea* was originally copied. Nor was he startled in the application of this rule, by the consideration, that it would force him to condemn, as insignificant, many words which are to be found in all languages, and some of which express what are commonly regarded as the most important objects of human knowledge. Of this number are the words *cause* and *effect;* at least, in the sense in which they are commonly understood both by the vulgar and by philosophers. "One event (says he) follows another; but we never observe any tie between them. They seem *conjoined*, but never *connected*. And as we can have no idea of any thing which never appeared to our outward sense or inward sentiment, the necessary conclusion seems to be, that we have no idea of connection or power at all; and that these words are absolutely without any meaning, when employed either in philosophical reasonings or common life."—(Hume's *Essays*, Vol. II. p. 79. Ed. of Lond. 1784.)

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[1] The incidental reference made, by way of illustration, in the following passage, to our *instinctive conviction* of the permanency of the laws of Nature, encourages me to hope, that, among candid and intelligent inquirers, it is now received as an acknowledged fact in the Theory of the Human Mind.

" The anxiety men have in all ages shown to obtain a fixed standard of value, and that remarkable agreement of nations, dissimilar in all other customs, in the use of one medium, on account of its superior fitness for that purpose, is itself a convincing proof how essential it is to our social interests. The notion of its permanency, although it be conventional and arbitrary, and liable, in reality, to many causes of variation, yet had gained so firm a hold on the minds of men, as to resemble, in its effects on their conduct, that *instinctive conviction of the permanency of the laws of nature which is the foundation of all our reasoning.*"—(*A Letter to the Right Hon. R. Peel, M. P. for the University of Oxford*, by one of his Constituents. Second edition, p. 23.)

[2] The difference between the two opinions amounts to nothing more than this, whether our expectation of the continuance of the laws of nature results from a principle coëval with the first exercise of the senses; or whether it arises gradually from the accommodation of the order of our thoughts to the established order of physical events. " Nature (as Mr Hume himself observes) *may* certainly produce whatever can arise from habit; nay, habit is nothing but one of the principles of nature, and derives all its force from that origin.—(*Treatise of Human Nature*, Vol. I. p. 313.) Whatever ideas, therefore, and whatever principles we are unavoidably led to acquire by the circumstances in which we are placed, and by the exercise of those faculties which are essential to our preservation, are to be considered as parts of human nature, no less than those which are implanted in the mind at its first formation. Are not the acquired perceptions of sight and of hearing as much parts of human nature as the original perceptions of external objects which we obtain by the use of the hand? The passage quoted from Mr Hume, in Note 2. p. 212, if attentively considered, will be found, when combined with these remarks, to throw a strong and pleasing light on his latest views with respect to this part of his philosophy.

In denying that our expectation of the continuance of the laws of nature is founded on reasoning, as well as in asserting our ignorance of any necessary connections among physical events, Mr Hume had been completely anticipated by some of his predecessors.—(See the references mentioned in the Note, p. 211.) I do not, however, think that, before his time, philosophers were at all aware of the alarming consequences which, on a superficial view, *seem* to follow from this part of his system. Indeed, these consequences would never have been apprehended, had it not been supposed to form an essential link in his argument against the commonly received notion of Causation.

When this doctrine was first proposed by Mr Hume, he appears to have been very strongly impressed with its repugnance to the common apprehensions of mankind. "I am sensible (he observes) that of all the paradoxes which I have had, or shall hereafter have occasion to advance in the course of this treatise, the present one is the most violent."—(*Treatise of Human Nature*, Vol. I. p. 291.) It was probably owing to this impression that he did not fully unfold in that work all the consequences which, in his subsequent publications, he deduced from the same paradox; nor did he even apply it to invalidate the argument which infers the existence of an *intelligent* cause from the order of the universe. There cannot, however, be a doubt that he was aware, at this period of his life, of the conclusions to which it unavoidably leads, and which are indeed too obvious to escape the notice of a far less acute inquirer.

In a private letter of Mr Hume's, to one of his most intimate friends,[1] some light is thrown on the circumstances which first led his mind into this train of sceptical speculation. As his narrative has every appearance of the most perfect truth and candour, and contains several passages which I doubt not will be very generally interesting to my readers, I shall give it a place, together with some extracts from the correspondence to which it gave rise, in the Notes at the end of this *Dissertation*. Every thing connected with the origin and composition of a work which has had so powerful an influence on the direction which metaphysical pursuits have since taken, both in Scotland[2] and in Germany, will be allowed to form an important article of philosophical history; and this history I need not offer any apology for choosing to communicate to the public rather in Mr Hume's words than in my own.[3]

From the reply to this letter by Mr Hume's very ingenious and accomplished correspondent, we learn that he had drawn from Mr Hume's metaphysical discussions the only sound and philosophical inference: that the lameness of the proofs offered by Descartes and his successors, of some fundamental truths universally

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[1] Sir Gilbert Elliot, Bart. grandfather of the present Earl of Minto. The originals of the letters to which I refer are in Lord Minto's possession.

[2] A foreign writer, of great name (M. Frederick Schlegel), seems to think that the influence of Mr Hume's *Treatise of Human Nature* on the Philosophy of England has been still more extensive than I had conceived it to be. His opinion on this point I transcribe as a sort of literary curiosity:

"Since the time of Hume, nothing more has been attempted in England, than to erect all sorts of bulwarks against the practical influence of his destructive scepticism; and to maintain, by various substitutes and aids, the pile of moral principle uncorrupted and entire. *Not only with Adam Smith, but with all their late philosophers, national welfare is the ruling and central principle of thought;—a principle excellent and praiseworthy in its due situation, but quite unfitted for being the centre and oracle of all knowledge and science.*" From the connection in which this last sentence stands with the context, would not one imagine that the writer conceived the *Wealth of Nations* to be a new *moral* or *metaphysical* system, devised by Mr Smith, for the purpose of counteracting Mr Hume's scepticism?

I have read this translation of Mr Schlegel's lectures with much curiosity and interest, and flatter myself that we shall soon have English versions of the works of Kant, and of other German authors, from the pens of their English disciples. Little more, I am fully persuaded, is necessary, in this country, to bring down the philosophy of Germany to its proper level.

In treating of literary and historical subjects, Mr Schlegel seems to be more in his element, than when he ventures to pronounce on philosophical questions. But even in cases of the former description, some of his dashing judgments on English writers can be accounted for only by haste, caprice, or prejudice. "The English themselves (we are told) are now pretty well convinced, that Robertson is a careless, superficial, and blundering historian: although they study his works, and are right in doing so, as models of pure composition, extremely deserving of attention during the present declining state of English style . . . . With all the abundance of his Italian elegance, what is the overloaded and affected Roscoe when compared with Gibbon? Coxe, although master of a good and classical style, resembles Robertson in no respect so much as in the superficialness of his researches; and the statesman Fox has nothing in common with Hume but the bigotry of his party zeal." Such criticisms may perhaps be applauded by a German auditory, but in this country they can injure the reputation of none but their author.

[3] See Note C C C.

acknowledged by mankind, proceeded, not from any defect in the evidence of these truths, but, on the contrary, from their being *self-evident*, and consequently unsusceptible of demonstration. We learn, farther, that the same conclusion had been adopted, at this early period, by another of Mr Hume's friends, Mr Henry Home, who, under the name of Lord Kames, was afterwards so well known in the learned world. Those who are acquainted with the subsequent publications of this distinguished and most respectable author, will immediately recognise, in the account here given of the impression left on his mind by Mr Hume's scepticism, the rudiments of a peculiar logic, which runs more or less through all his later works; and which, it must be acknowledged, he has, in various instances, carried to an unphilosophical extreme.[1]

The light in which Mr Hume's scepticism appears from these extracts to have struck his friends, Sir Gilbert Elliot and Lord Kames, was very nearly the same with that in which it was afterwards viewed by Reid, Oswald, and Beattie, all of whom have manifestly aimed, with greater or less precision, at the same logical doctrine which I have just alluded to. This, too, was the very ground on which Father Buffier had (even before the publication of the *Treatise of Human Nature)* made his stand against similar theories, built by his predecessors on the Cartesian principles. The coincidence between his train of thinking, and that into which our Scottish metaphysicians soon after fell, is so very remarkable, that it has been considered by many as amounting to a proof that the plan of their works was, in some measure, suggested by his; but it is infinitely more probable, that the argument which runs, in common, through the speculations of all of them, was the natural result of the state of metaphysical science when they engaged in their philosophical inquiries.[2]

The answer which Mr Hume made to this argument, when it was first proposed to him in the easy intercourse of private correspondence, seems to me an object of so much curiosity, as to justify me for bringing it under the eye of my readers in immediate connection with the foregoing details. Opinions thus communicated in the confidence of friendly discussion, possess a value which seldom belongs to propositions hazarded in those public controversies where the love of victory is apt to mingle, more or less, in the most candid minds, with the love of truth.

"Your notion of correcting subtlety by *sentiment* is certainly very just with regard to morals, which depend upon sentiment: And in politics and natural philosophy, whatever conclusion is contrary to certain matters of fact, must certainly be wrong, and there must some error lie somewhere in the argument, whether we be able to show it or not. But, in metaphysics or theology, I cannot see how either of these plain and obvious standards of truth can have place. Nothing there can correct bad reasoning but good reasoning; and sophistry must be opposed by syllogism.[3] About seventy or eighty years ago,[4] I observe a principle like that which you advance prevailed very much in France, amongst some philosophers and beaux esprits.

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[1] I allude particularly to the unnecessary multiplication, in his philosophical arguments, of internal senses and of instinctive principles.

[2] Voltaire, in his catalogue of the illustrious writers who adorned the reign of Louis XIV. is one of the very few French authors who have spoken of Buffier with due respect: "Il y a dans ses traités de métaphysique des morceaux que Locke n'aurait pas désavoués, et c'est le seul jésuite qui ait mis une philosophie raisonnable dans ses ouvrages."—Another French philosopher, too, of a very different school, and certainly not disposed to overrate the talents of Buffier, has, in a work published as lately as 1805, candidly acknowledged the lights which he might have derived from the labours of his predecessor, if he had been acquainted with them at an earlier period of his studies. Condillac, he also observes, might have profited greatly by the same lights, if he had availed himself of their guidance, in his inquiries concerning the human understanding. "Du moins est il certain que pour ma part, je suis fort faché de ne connôitre que depuis très peu de temps ces opinions du Père Buffier; si je les avais vues plutôt énoncées quelque part, elles m'auraient épargné beaucoup de peines et d'hésitations."—"Je regrette beaucoup que Condillac, dans ses profondes et sagaces méditations sur l'intelligence humaine, n'ait pas fait plus d'attention aux idées du Père Buffier," &c. &c.—*Elémens d'Idéologie*, par M. DESTUTT-TRACY, Tom. III. pp. 136, 137. (See *Elements of the Philosophy of the Human Mind*, Vol. II. pp. 88, 89, 2d edit.)

[3] May not sophistry be also opposed, by appealing to the *fundamental laws of human belief;* and, in some cases, by appealing to *facts* for which we have the evidence of our own consciousness? The word *sentiment* does not express, with sufficient precision, the test which Mr Hume's correspondent had manifestly in view.

[4] This letter is dated 1751.

The occasion of it was this: The famous M. Nicole of the Port Royal, in his *Perpetuité de la Foi*, pushed the Protestants very hard upon the impossibility of the people's reaching a conviction of their religion by the way of private judgment, which required so many disquisitions, reasonings, researches, erudition, impartiality, and penetration, as not one of a hundred, even among men of education, is capable of. M. Claude and the Protestants answered him, not by solving his difficulties (which seems impossible), but by retorting them (which is very easy.) They showed, that to reach the way of authority which the Catholics insist on, as long a train of acute reasoning, and as great erudition was requisite, as would be sufficient for a Protestant. We must first prove all the truths of natural religion, the foundation of morals, the divine authority of the Scripture, the deference which it commands to the church, the tradition of the church, &c. &c. The comparison of these controversial writings begat an idea in some, that it was neither by reasoning nor authority we learn our religion, but by sentiment; and this was certainly a very convenient way, and what a philosopher would be very well pleased to comply with, if he could distinguish sentiment from education. But, to all appearance, the sentiment of Stockholm, Geneva, Rome, ancient and modern Athens, and Memphis, have not the same characters; and no thinking man can implicitly assent to any of them, but from the general principle, that, as the truth on these subjects is beyond human capacity, and that, as for one's own ease, he must adopt some tenets, there is more satisfaction and convenience in holding to the catechism we have been first taught. Now, this I have nothing to say against. I would only observe, that such a conduct is founded on the most universal and determined scepticism. For more curiosity and research give a direct opposite turn from the same principles."

On this careless effusion of Mr Hume's pen, it would be unpardonable to offer any critical strictures. It cannot, however, be considered as improper to hint, that there is a wide and essential difference between those articles of faith which formed the subjects of dispute between Nicole and Claude, and those *laws of belief*, of which it is the great object of the *Treatise of Human Nature* to undermine the authority. The reply of Mr Hume, therefore, is evasive, and although strongly marked with the writer's ingenuity, does not bear upon the point in question.

As to the distinction alleged by Mr Hume between the *criteria* of truth in natural philosophy and in metaphysics, I trust it will now be pretty generally granted, that however well founded it may be when confined to the metaphysics of the schoolmen, it will by no means hold when extended to the inductive philosophy of the human mind. In this last science, no less than in natural philosophy, Mr Hume's logical maxim may be laid down as a fundamental principle, that "whatever conclusion is contrary to matter of fact must be wrong, and there must some error lie somewhere in the argument, whether we be able to show it or not."

It is a remarkable circumstance in the history of Mr Hume's literary life, and a proof of the sincerity with which he was then engaged in the search of truth, that, previous to the publication of his *Treatise of Human Nature*, he discovered a strong anxiety to submit it to the examination of the celebrated Dr Butler, author of the *Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature.* For this purpose he applied to Mr Henry Home, between whom and Dr Butler some friendly letters appear to have passed before this period. "Your thoughts and mine (says Mr Hume to his correspondent) agree with respect to Dr Butler, and I would be glad to be introduced to him. I am at present castrating my work, that is, cutting off its nobler parts; that is, endeavouring it shall give as little offence as possible, before which I could not pretend to put it into the doctor's hands."[1] In another letter, he acknowledges Mr Home's kindness in recommending him to Dr Butler's notice. "I shall not trouble you with any formal compliments or thanks, which would be but an ill return for the kindness you have done me in writing in my behalf, to one you are so little acquainted with as Dr Butler; and, I am afraid, stretching the truth in favour of a friend. I have called on the doctor, with a design of delivering your letter, but find he is at present in the country. I am a little anxious to have the doctor's opinion. My own I dare not trust to; both because it concerns myself, and because it is so variable, that I know not how to fix it. Sometimes it elevates me above the clouds; at other times it depresses me with doubts and fears; so that, whatever be my success, I cannot be entirely disappointed."

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[1] For the rest of the letter, see *Memoirs of the Life and Writings of Lord Kames*, by Lord Woodhouselee, Vol. I. p. 84, *et seq.*

Whether Mr Hume ever enjoyed the satisfaction of a personal interview with Dr Butler, I have not heard. From a letter of his to Mr Home, dated London, 1739, we learn that if any intercourse took place between them, it must have been after the publication of the *Treatise of Human Nature.* "I have sent the Bishop of Bristol a copy; but could not wait upon him with your letter after he had arrived at that dignity. At least, I thought it would be to no purpose after I began the printing."[1] In a subsequent letter to the same correspondent, written in 1742, he expresses his satisfaction at the favourable opinion which he understood Dr Butler had formed of his volume of *Essays*, then recently published, and augurs well from this circumstance of the success of his book. "I am told that Dr Butler has everywhere recommended them, so that I hope they will have some success."[2]

These particulars, trifling as they may appear to some, seemed to me, for more reasons than one, not unworthy of notice in this sketch. Independently of the pleasing record they afford of the mutual respect entertained by the eminent men to whom they relate, for each other's philosophical talents, they have a closer connection with the history of metaphysical and moral inquiry in this island, than might be suspected by those who have not a very intimate acquaintance with the writings of both. Dr Butler was, I think, the first of Mr Locke's successors who clearly perceived the dangerous consequences likely to be deduced from his account of the origin of our ideas literally interpreted; and although he has touched on this subject but once, and that with his usual brevity, he has yet said enough to show, that his opinion with respect to it was the same with that formerly contended for by Cudworth, in opposition to Gassendi and Hobbes, and which has since been revived in different forms by the ablest of Mr Hume's antagonists.[3] With these views, it may be reasonably supposed, that he was not displeased to see the consequences of Locke's doctrine so very logically and forcibly pushed to their utmost limits, as the most effectual means of rousing the attention of the learned to a re-examination of this fundamental principle. That he was perfectly aware, before the publication of Mr Hume's work, of the encouragement given to scepticism by the logical maxims then in vogue, is evident from the concluding paragraph of his short *Essay on Personal Identity.* Had it been published a few years later, nobody would have doubted, that it had been directly pointed at the general strain and spirit of Mr Hume's philosophy.

"But though we are thus certain, that we are the same agents or living beings *now*, which we were as far back as our remembrance reaches: yet it is asked, Whether we may not possibly be deceived in it? And this question may be asked at the end of any demonstration whatever, because it is a question concerning the truth of perception by memory. And he who can doubt, whether perception by memory can in this case be depended on, may doubt also whether perception by deduction and reasoning, which also includes memory, or indeed whether intuitive perception can. Here then we can go no farther. For it is ridiculous to attempt to prove the truth of those perceptions whose truth we can no otherwise prove than by other perceptions of exactly the same kind with them, and which there is just the same ground to suspect; or to attempt to prove the truth of our faculties, which can no otherwise be proved, than by the use or means of those very suspected faculties themselves."[1]

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[1] *Memoirs of the Life and Writings of Lord Kames*, Vol. I. p. 92.

[2] *Ibid.* p. 404. The *Essays* here referred to were the first part of the Essays Moral, Political, and Literary, published in 1742. The elegant author of these Memoirs has inadvertently confounded this volume with the second part of that work, containing the *Political Discourses* (properly so called), which did not appear till ten years afterwards.

[3] See the short *Essay on Personal Identity*, at the end of Butler's *Analogy;* and compare the second paragraph with the remarks on this part of Locke's *Essay* by Dr Price. (*Review of the Principal Questions and Difficulties relating to Morals*, pp. 49, 50. 3d ed. Lond. 1787.)

It is, however, less as a speculative metaphysician, than as a philosophical inquirer into the principles of morals, that I have been induced to associate the name of Butler with that of Hume. And, on this account, it may be thought that it would have been better to delay what I have now said of him till I come to trace the progress of Ethical Science during the eighteenth century. To myself it seemed more natural and interesting to connect this historical or rather biographical digression, with the earliest notice I was to take of Mr Hume as an author. The numerous and important hints on metaphysical questions which are scattered over Butler's works, are sufficient of themselves to account for the space I have allotted to him among Locke's successors; if, indeed, any apology for this be necessary, after what I have already mentioned, of Mr Hume's ambition to submit to his judgment the first fruits of his metaphysical studies.

The remarks hitherto made on the *Treatise of Human Nature* are confined entirely to the first volume. The speculations contained in the two others, on Morals, on the Nature and Foundations of Government, and on some other topics connected with political philosophy, will fall under our review afterwards.

Dr Reid's *Inquiry into the Human Mind* (published in 1764) was the first direct attack which appeared in Scotland upon the sceptical conclusions of Mr Hume's philosophy. For my own opinion of this work I must refer to one of my former publications.[2] It is enough to remark here, that its great object is to refute the *Ideal Theory* which was then in complete possession of the schools, and upon which Dr Reid conceived that the whole of Mr Hume's philosophy, as well as the whole of Berkeley's reasonings against the existence of matter, was founded. According to this theory we are taught, that "nothing is perceived but what is in the mind which perceives it; that we do not really perceive things that are external, but only certain images and pictures of them imprinted upon the mind, which are called impressions and ideas."—"This doctrine (says Dr Reid on another occasion) I once believed so firmly, as to embrace the whole of Berkeley's system along with it; till finding other consequences to follow from it, which gave me more uneasiness than the want of a material world, it came into my mind, more than forty years ago, to put the question, What evidence have I for this doctrine, that all the objects of my knowledge are ideas in my own mind? From that time to the present, I have been candidly and impartially, as I think, seeking for the evidence of this principle; but can find none, excepting the authority of philosophers."

On the refutation of the ideal theory, contained in this and his other works, Dr Reid himself was disposed to rest his chief merit as an author. "The merit (says he in a letter to Dr James Gregory) of what you are pleased to call *my Philosophy*, lies, I think, chiefly in having called in question the common theory of ideas or images of things in the mind being the only objects of thought; a theory founded on natural prejudices, and so universally received as to be interwoven with the structure of language. Yet were I to give you a detail of what led me to call in question this theory, after I had long held it as self-evident and unquestionable, you would think, as I do, that there was much of chance in the matter. The discovery was the birth of time, not of genius; and Berkeley and Hume did more to bring it to light than the man that hit upon it. I think there is hardly any thing that can be called *mine* in the philosophy of the mind, which does not follow with ease from the detection of this prejudice.

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[1] I must not, however, be understood as giving unqualified praise to this Essay. It is by no means free from the old scholastic jargon, and contains some reasoning which, I may confidently assert, the author would not have employed, had it been written fifty years later. Whoever takes the trouble to read the paragraph beginning with these words, "*Thirdly*, Every person is conscious," &c. will immediately perceive the truth of this remark. I mention it as a proof of the change to the better, which has taken place since Butler's time, in the mode of thinking and writing on Metaphysical questions.

[2] See *Biographical Memoirs*, Edin. 1811.

"I must, therefore, beg of you, most earnestly, to make no contrast in my favour to the disparagement of my predecessors in the same pursuits. I can truly say of them, and shall always avow, what you are pleased to say of me, that, but for the assistance I have received from their writings, I never could have wrote or thought what I have done."[1]

When I reflect on the stress thus laid by Dr Reid on this part of his writings, and his frequent recurrence to the same argument whenever his subject affords him an opportunity of forcing it upon the attention of his readers, I cannot help expressing my wonder, that Kant and other German philosophers, who appear to have so carefully studied those passages in Reid, which relate to Hume's Theory of Causation, should have overlooked entirely what he himself considered as the most original and important of all his discussions; more especially as the conclusion to which it leads has been long admitted, by the best judges in this island, as one of the few propositions in metaphysical science completely established beyond the reach of controversy. Even those who affect to speak the most lightly of Dr Reid's contributions to the philosophy of the human mind, have found nothing to object to his reasonings against the ideal theory, but that the absurdities involved in it are too glaring to require a serious examination.[2] Had these reasonings been considered in the same light in Germany, it is quite impossible that the analogical language of Leibnitz, in which he speaks of the soul as *a living mirror of the universe*, could have been again revived; a mode of speaking liable to every objection which Reid has urged against the ideal theory. Such, however, it would appear, is the fact. The word *Representation (Vorstellung)* is now the German substitute for *Idea;* nay, one of the most able works which Germany has produced since the commencement of its new philosophical era, is entitled *Nova Theoria Facultatis Representativæ Humanæ*. In the same work, the author has prefixed, as a motto to the second book, in which he treats of "the *Representative Faculty* in general," the following sentence from Locke, which he seems to have thought himself entitled to assume as a first principle: "Since the mind, in all its thoughts and reasonings, hath no other *immediate* object but its own *ideas (representations)*, which it alone does or can contemplate, it is evident that our knowledge is only conversant about them."—(LOCKE's *Essay*, B. IV. ch. 1.) In a country where this metaphysical jargon still passes current among writers of eminence, it is vain to expect that any solid progress can be made in the inductive philosophy of the human mind. A similar remark may be extended to another country, where the title of *Ideologie* (a word which takes for granted the truth of the hypothesis which it was Reid's great aim to explode) has been lately given to the very science in which the theory of *Ideas* has been so clearly shown to have been, in all ages, the most fruitful source of error and absurdity.[1]

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[1] An ingenious and profound writer, who, though intimately connected with Mr Hume in habits of friendship, was not blind to the vulnerable parts of his Metaphysical System, has bestowed, in the latest of his publications, the following encomium on Dr Reid's *Philosophical Works*.

"The author of an *Inquiry into the Mind*, and of subsequent *Essays on the Intellectual and Active Powers of Man*, has great merit in the effect to which he has pursued this history. But, considering the point at which the science stood when he began his inquiries, he has, perhaps, no less merit in having removed the mist of hypothesis and metaphor, with which the subject was enveloped; and, in having taught us to state the facts of which we are conscious, not in figurative language, but in the terms which are proper to the subject. In this it will be our advantage to follow him; the more that, in former theories, so much attention had been paid to the introduction of *ideas* or *images* as the elements of knowledge, that the belief of any external existence or prototype has been left to be inferred from the mere idea or image; and this inference, indeed, is so little founded, that many who have come to examine its evidence have thought themselves warranted to deny it altogether. And hence the scepticism of ingenious men, who, not seeing a proper access to knowledge through the medium of ideas, without considering whether the road they had been directed to take was the true or a false one, denied the possibility of arriving at the end."—*(Principles of Moral and Political Science*, by Dr Adam Ferguson, Vol. I. pp. 75, 76.)

The work from which this passage is taken contains various important observations connected with the Philosophy of the Human Mind; but as the taste of the author led him much more strongly to moral and political speculations, than to researches concerning the intellectual powers of man, I have thought it right to reserve any remarks which I have to offer on his philosophical merits for the last part of this Discourse.

[2] I allude here more particularly to Dr Priestley, who, in a work published in 1774, alleged, that when philosophers called ideas the *images* of external things, they are only to be understood as speaking figuratively; and that Dr Reid has gravely argued against this metaphorical language, as if it were meant to convey a theory of perception. The same remark has been repeated over and over since Priestley's time, by various writers. I have nothing to add in reply to it to what I long ago stated in my Philosophical Essays (see Note H. at the end of that work), but the following short quotation from Mr Hume:—

"It seems evident, that, when men follow this blind and powerful instinct of nature, they always suppose the very images, presented by the senses, to be the external objects, and never entertain any suspicion, that the one are nothing but *representations* of the other. * * * * But this universal and primary opinion of all men is soon destroyed by the slightest philosophy, which teaches us, that nothing can ever be present to the mind but an *image* or perception, and that the senses are only the inlets through which these images are conveyed, without being able to produce any immediate intercourse between the mind and the object. The table which we see seems to diminish as we remove farther from it; but the real table, which exists independent of us, suffers no alteration. It was, therefore, nothing but its image which was present to the mind. These are the obvious dictates of reason."—*(Essay on the Academical Philosophy.)*

Is not this analogical theory of perception the principle on which the whole of Berkeley's reasonings against the existence of the material world, and of Hume's scepticism on the same subject, are founded?

The same analogy still continues to be sanctioned by some English philosophers of no small note. Long after the publication of Dr Reid's *Inquiry*, Mr Horne Tooke quoted with approbation the following words of J. C. Scaliger: "Sicut in speculo ea quæ videntur non sunt, sed eorum *species;* ita quæ intelligimus, ea sunt re ipsa extra nos, eorumque *species* in nobis. EST ENIM QUASI RERUM SPECULUM INTELLECTUS NOSTER; CUI, NISI PER SENSUM REPRESENTENTUR RES, NIHIL SCIT IPSE."—(J. C. SCALIGER, *de Causis*, L. I. cap. lxvi.) *Diversions of Purley*, Vol. I. p. 35, 2d. Edition.

Of the other works by Scottish metaphysicians, which appeared soon after the *Inquiry into the Human Mind*, I have not left myself room to speak. I know of none of them from which something important may not be learned; while several of them (particularly those of Dr Campbell) have struck out many new and interesting views. To one encomium all of them are well entitled, that of aiming steadily at the advancement of useful knowledge and of human happiness. But the principles on which they have proceeded have so close an affinity to those of Dr Reid, that I could not, without repeating what I have already said, enter into any explanation concerning their characteristical doctrines.

On comparing the opposition which Mr Hume's scepticism encountered from his own countrymen, with the account formerly given of the attempts of some German philosophers to refute his Theory of Causation, it is impossible not to be struck with the coincidence between the leading views of his most eminent antagonists. This coincidence one would have been disposed to consider as purely accidental, if Kant, by his petulant sneers at Reid, Beattie, and Oswald, had not expressly acknowledged, that he was not unacquainted with their writings. As for the great discovery, which he seems to claim as his own,—that the ideas of Cause and Effect, as well as many others, are derived from the *pure understanding* without any aid from experience, it is nothing more than a repetition, in very nearly the same terms, of what was advanced a century before by Cudworth, in reply to Hobbes and Gassendi; and borrowed avowedly by Cudworth from the reasonings of Socrates, as reported by Plato, in answer to the scepticism of Protagoras. This recurrence, under different forms, of the same metaphysical controversies, which so often surprises and mortifies us in the history of literature, is an evil which will probably always continue, more or less, even in the most prosperous state of philosophy. But it affords no objection to the utility of metaphysical pursuits. While the sceptics keep the field, it must not be abandoned by the friends of sounder principles; nor ought they to be discouraged from their ungrateful task, by the reflection, that they have probably been anticipated, in everything they have to say, by more than one of their predecessors. If any thing is likely to check this periodical return of a mischief so unpropitious to the progress of useful knowledge, it seems to be the general diffusion of that historical information concerning the literature and science of former times, of which it is the aim of these Preliminary Dissertations to present an outline. Should it fail in preventing the occasional revival of obsolete paradoxes, it will, at least, diminish the wonder and admiration with which they are apt to be regarded by the multitude.

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[1] In censuring these metaphorical terms, I am far from supposing that the learned writers who have employed them have been all misled by the theoretical opinions involved in their language. Reinhold has been more particularly careful in guarding against such a misapprehension. But it cannot, I think, be doubted that the prevalence of such a phraseology must have a tendency to divert the attention from a just view of the mental phenomena, and to infuse into the mind of the young inquirer very false conceptions of the manner in which these phenomena ought to be studied.

And here I cannot refrain from remarking the injustice with which the advocates for truth are apt to be treated; and by none more remarkably than by that class of writers who profess the greatest zeal for its triumph. The importance of their labours is discredited by those who are the loudest in their declamations and invectives against the licentious philosophy of the present age; insomuch that a careless observer would be inclined to imagine (if I may borrow Mr Hume's words on another occasion), that the battle was fought "not by the men at arms, who manage the pike and the sword; but by the trumpeters, drummers, and musicians, of the army."

These observations may serve, at the same time, to account for the slow and (according to some persons) imperceptible advances of the philosophy of the human mind, since the publication of Locke's *Essay*. With those who still attach themselves to that author, as an infallible guide in metaphysics, it is in vain to argue; but I would willingly appeal to any of Locke's rational and discriminating admirers, whether much has not been done by his successors, and, among others, by members of our northern universities, towards the illustration and correction of such of his principles as have furnished, both to English and French sceptics, the foundation of their theories.[1] If this be granted, the way has, at least, been cleared and prepared for the labours of our posterity; and neither the cavils of the sceptic, nor the refutation of them by the sounder logician, can be pronounced to be useless to mankind. Nothing can be juster or more liberal than the following reflection of Reid: "I conceive the sceptical writers to be a set of men, whose business it is to pick holes in the fabric of knowledge wherever it is weak and faulty; and when those places are properly repaired, the whole building becomes more firm and solid than it was formerly."—(*Inquiry into the Human Mind.* Dedication.)

There is, indeed, one point of view, in which it must be owned that Mr Hume's *Treatise* has had an unfavourable effect (and more especially in Scotland) on the progress of Metaphysical Science. Had it not been for the zeal of some of his countrymen to oppose the sceptical conclusions, which they conceived it to be his aim to establish, much of that ingenuity which has been wasted in the refutation of his sophistry (or, to speak more correctly, in combating the mistaken principles on which he proceeded) would, in all probability, have been directed to speculations more immediately applicable to the business of life, or more agreeable to the taste of the present age. What might not have been expected from Mr Hume himself, had his powerful and accomplished mind been more frequently turned to the study of some parts of our nature (of those, for example, which are connected with the principles of criticism), in examining which, the sceptical bias of his disposition would have had fewer opportunities of leading him astray! In some fragments of this sort, which enliven and adorn his collection of *Essays*, one is at a loss whether more to admire the subtlety of his genius, or the solidity and good sense of his critical judgments.

Nor have these elegant applications of metaphysical pursuits been altogether overlooked by Mr Hume's antagonists. The active and adventurous spirit of Lord Kames, here, as in many other instances, led the way to his countrymen; and, due allowances being made for the novelty and magnitude of his undertaking, with a success far greater than could have been reasonably anticipated. The *Elements of Criticism*, considered as the first systematical attempt to investigate the metaphysical principles of the fine arts, possesses, in spite of its numerous defects both in point of taste and of philosophy, infinite merits, and will ever be regarded as a literary wonder by those who know how small a portion of his time it was possible for the author to allot to the composition of it, amidst the imperious and multifarious duties of a most active and useful life. Campbell and Gerard, with a sounder philosophy, and Beattie, with a much more lively relish for the Sublime and the Beautiful, followed afterwards in the same path; and have all contributed to create and to diffuse over this island a taste for a higher and more enlightened species of criticism than was known to our forefathers. Among the many advantageous results with which this study has been already attended, the most important, undoubtedly, is the new and pleasing avenue which it has opened to an analysis of the laws which regulate the intellectual phenomena; and the interest which it has thus lent, in the estimation of men of the world, to inquiries which, not many years before, were seldom heard of, but within the walls of an university.

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[1] According to Dr Priestley, the labours of these commentators on Locke have done more harm than good. "I think Mr Locke has been hasty in concluding that there is some other source of our ideas besides the external senses; but the rest of his system appears to me and others to be the corner stone of all just and rational knowledge of ourselves."

"This solid foundation, however, has lately been attempted to be overturned by a set of pretended philosophers, of whom the most conspicuous and assuming is Dr Reid, Professor of Moral Philosophy in the University of Glasgow."—(*Exam. of Reid, Beattie, and Oswald*, p. 5.)—As to Mr Hume, Dr Priestley says, "In my opinion, he has been *very ably* answered, again and again, upon more solid principles than those of this new *common sense; and I beg leave to refer to the two first volumes of my Institutes of Natural and Revealed Religion.*"—(*Examination of Reid*, &c. Preface, p. xxvii.

Dr Reid's two volumes of *Essays on the Intellectual and on the Active Powers of Man* (the former of which appeared in 1785, and the latter in 1788) are the latest philosophical publications from Scotland of which I shall at present take notice. They are less highly finished, both in matter and in form, than his *Inquiry into the Human Mind.* They contain also some repetitions, to which, I am afraid, I must add a few trifling inconsistencies of expression, for which the advanced age of the author, who was then approaching to fourscore, claims every indulgence from a candid reader. Perhaps, too, it may be questioned, whether, in one or two instances, his zeal for an important conclusion has not led him to avail himself of some dubious reasonings, which might have been omitted without any prejudice to his general argument. "The value of these volumes, however (as I have elsewhere remarked), is inestimable to future adventurers in the same arduous inquiries, not only in consequence of the aids they furnish as a rough draught of the field to be examined, but by the example they exhibit of a method of investigation on such subjects, hitherto very imperfectly understood, even by those philosophers who call themselves the disciples of Locke. It is by the logical rigour of this method, so systematically pursued in all his researches, still more than by the importance of his particular conclusions, that he stands so conspicuously distinguished among those who have hitherto prosecuted analytically the study of man." [1]

His acquaintance with the metaphysical doctrines of his predecessors does not appear to have been very extensive; with those of his own contemporaries it was remarkably deficient. I do not recollect that he has anywhere mentioned the names either of Condillac or of D'Alembert. It is impossible not to regret this, not only as it has deprived us of his critical judgments on some celebrated theories, but as it has prevented him from enlivening his works with that variety of historical discussion so peculiarly agreeable in these abstract researches.

On the other hand, Dr Reid's limited range of metaphysical reading, by forcing him to draw the materials of his philosophical speculations almost entirely from his own reflections, has given to his style, both of thinking and of writing, a characteristical unity and simplicity seldom to be met with in so voluminous an author. He sometimes, indeed, repeats, with an air of originality, what had been previously said by his predecessors; but on these, as on all other occasions, he has at least the merit of thinking for himself, and of sanctioning, by the weight of his unbiassed judgment, the conclusions which he adopts. It is this uniformity of thought and design, which, according to Dr Butler, is the best test of an author's sincerity; and I am apt to regard it also, in these abstruse disquisitions, as one of the surest marks of liberal and unfettered inquiry.

In comparing Dr Reid's publications at different periods of his life, it is interesting to observe his growing partiality for the aphoristical style. Some of his *Essays on the Intellectual and Active*

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[1] *Biographical Account of Reid.*

Powers of Man are little more than a series of detached paragraphs, consisting of leading thoughts, of which the reader is left to trace the connection by his own sagacity. To this aphoristical style it is not improbable that he was partly led by the indolence incident to advanced years, as it relieved him from what Boileau justly considered as the most difficult task of an author, the skilful management of *transitions.*[1] In consequence of this want of continuity in his compositions, a good deal of popular effect is unavoidably lost; but, on the other hand, to the few who have a taste for such inquiries, and who value books chiefly as they furnish exercise to their own thoughts (a class of readers who are alone competent to pronounce a judgment on metaphysical questions), there is a peculiar charm in a mode of writing, so admirably calculated to give *relief* to the author's ideas, and to awaken, at every sentence, the reflections of his readers.

When I review what I have now written on the history of Metaphysics in Scotland, since the publication of Mr Hume's *Treatise*, and at the same time recollect the laurels which, during the same period, have been won by Scottish authors, in every other department of literature and of science, I must acknowledge that, instead of being mortified at the slender amount of their contributions to the philosophy of the human mind, I am more disposed to wonder at their successful perseverance in cultivating a field of study, where the approbation of a few enlightened and candid judges is the only reward to which their ambition could aspire. Small as their progress may hitherto have been, it will at least not suffer by a comparison with what has been accomplished by their contemporaries in any other part of Europe.

It may not be useless to add in this place, that, if little has as yet been done, the more ample is the field left for the industry of our successors. The compilation of a *Manual of Rational Logic*, adapted to the present state of science and of society in Europe, is a *desideratum* which, it is to be hoped, will at no distant period be supplied. It is a work, certainly, of which the execution has been greatly facilitated by the philosophical labours of the last century. The varieties of intellectual character among men present another very interesting object of study, which, considering its practical utility, has not yet excited, so much as might have been expected, the curiosity of our countrymen. Much, too, is still wanting to complete the theory of evidence. Campbell has touched upon it with his usual acuteness, but he has attempted nothing more than an illustration of a very few general principles. Nor has he turned his attention to the various illusions of the imagination, and of the passions, by which the judgment is liable to be warped in the estimates it forms of moral evidence in the common affairs of life. This is a most important inquiry, considering how often the lives and fortunes of men are subjected to the decisions of illiterate persons concerning circumstantial proofs; and how much the success or failure of every individual in the conduct of his private concerns turns on the sagacity or rashness with which he anticipates future contingencies. Since the time when Campbell wrote, an attempt has been made by Condorcet[2] and some other French writers, to apply a mathematical calculus to moral and political truths; but though much metaphysical ingenuity, as well as mathematical skill, have been displayed in carrying it into execution, it has not yet led to any useful practical results. Perhaps it may even be questioned, whether, in investigating truths of this sort, the intellectual powers can derive much aid from the employment of such an organ. To define accurately and distinctly the limits of its legitimate province, still remains a *desideratum* in this abstruse part of logic.

Nearly connected with this subject are the metaphysical principles assumed in the mathematical Calculation of Probabilities; in delivering which principles, some foreign mathematicians, with the illustrious La Place at their head, have blended, with many unquestionable and highly interesting conclusions, various moral paralogisms of the most pernicious tendency. A critical examination of these paralogisms, which are apt to escape the attention of the reader amid the variety of original and luminous discussions with which they are surrounded, would, in my humble apprehension, be one of the most essential services which could at present be rendered to true philosophy. In the mind of La Place, their origin may be fairly traced to an ambition, not altogether unnatural in so transcendant a genius, to extend the empire of his favourite science over the moral as well as the material world.[1] I have mentioned but a few out of the innumerable topics which crowd upon me as fit objects of inquiry for the rising generation.[2] Nor have I been guided in my selection of these by any other consideration, than their peculiar adaptation to the actual circumstances of the philosophical world.

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[1] Boileau is said, by the younger Racine, to have made this remark in speaking of La Bruyere: " Il disoit que La Bruyere s'etoit épargné *le plus difficile d'un ouvrage* en s'épargnant les transitions."—*Mémoire sur la Vie de Jean Racine.)*

[2] *Essai sur l'Application de l'Analyse à la Probabilité des Decisions rendues à la pluralite des Voix.*

Should such men as Hume, Smith, and Reid again arise, their curiosity would, in all probability, be turned to some applications of metaphysical principles of a more popular and practical nature than those which chiefly engaged their curiosity. At the same time, let us not forget what a step they made beyond the scholastic philosophy of the preceding age; and how necessary this step was as a preliminary to other researches bearing more directly and palpably on human affairs.

The most popular objection hitherto made to our Scottish metaphysicians is, that, in treating of human nature, they have overlooked altogether the corporeal part of our frame. From the contempt which they have uniformly expressed for all physiological theories concerning the intellectual phenomena, it has been concluded, that they were disposed to consider the human mind as altogether independent of the influence of physical causes. Mr Belsham has carried this charge so far, as to sneer at Dr Reid's inconsistency for having somewhere acknowledged, "in opposition to his systematical principles, that a certain constitution or state of the brain is necessary to memory." In reply to this charge, it may be confidently asserted, that no set of philosophers, since the time of Lord Bacon, have entertained juster views on this subject than the school to which Dr Reid belonged. In proof of this, I need only appeal to the *Lectures on the Duties and Qualifications of a Physician*, by the late learned and ingenious Dr John Gregory. Among the different articles connected with the natural history of the human species, which he has there recommended to the examination of the medical student, he lays particular stress on "the laws of union between the mind and body, and the mutual influence they have upon one another." "This (he observes) is one of the most important inquiries that ever engaged the attention of mankind, and almost equally necessary in the sciences of morals and of medicine." It must be remarked, however, that it is only the *laws* which regulate the union between mind and body (the same class of *facts* which Bacon called the *doctrina de fœdere)*, which are here pointed out as proper objects of philosophical curiosity; for as to any *hypothesis* concerning the *manner* in which the union is carried on, this most sagacious writer was well aware, that they are not more unfavourable to the improvement of logic and of ethics, than to a skilful and judicious exercise of the healing art.

I may perhaps form too high an estimate of the progress of knowledge during the last fifty years; but I think I can perceive, within the period of my own recollection, not only a change to the better in the Philosophy of the Human Mind, but in the speculations of medical inquirers. Physiological theories concerning the functions of the nerves in producing the intellectual phenomena have pretty generally fallen into contempt: and, on the other hand, a large accession has been made to our stock of well authenticated facts, both with respect to the influence of body on mind, and of mind upon body. As examples of this, it is sufficient to mention the experimental inquiries instituted, in consequence of the pretended cures effected by means of Animal Magnetism and of Tractors; to which may be added, the philosophical spirit evinced in some late publications on Insanity.

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[1] The paralogisms to which I allude did not fall within the scope of the admirable criticism on this work in the *Edinburgh Review*.

[2] Among these, the most prominent is the Natural or Theoretical History of Language (including under this title *written* as well as *oral* language), a subject which will probably continue to furnish new problems to human ingenuity, in the most improved state of human knowledge. It is not surprising that an art which lays the foundation of all the others, and which is so intimately connected with the exercise of reason itself, should leave behind it such faint and obscure traces of its origin and infancy.

Another objection, not so entirely groundless, which has been made to the same school, is, that their mode of philosophising has led to an unnecessary multiplication of our *internal senses and instinctive determinations.* For this error, I have elsewhere attempted to account and to apologise.[1] On the present occasion I shall only remark, that it is at least a safer error than the opposite extreme, so fashionable of late among our southern neighbours, of endeavouring to explain away, without any exception, all our *instinctive* principles, both speculative and practical. A literal interpretation of Locke's comparison of the infant mind to a *sheet of white paper* (a comparison which, if I am rightly informed, has not yet wholly lost its credit in all our universities), naturally predisposed his followers to embrace this theory, and enabled them to shelter it from a free examination, under the sanction of his supposed authority. Dr Paley himself, in his earliest philosophical publication, yielded so far to the prejudices in which he had been educated, as to dispute the existence of the *moral faculty;*[2] although, in his more advanced years, he amply atoned for this error of his youth, by the ingenuity and acuteness with which he combated the reasonings employed by some of his contemporaries, to invalidate the proofs afforded by the phenomena of *instinct*, of the existence of a designing and provident cause. In this part of his work, he has plainly in his eye the *Zoonomia* of Dr Darwin,[3] where the same principles, of which Paley and others had availed themselves to disprove the existence of instinct and instinctive propensities in man, are eagerly laid hold of to disprove the existence of *instinct* in the brutes. Without such an extension of the argument, it was clearly perceived by Darwin, that sufficient evidences of the existence of a Designing Cause would be afforded by the phenomena of the lower animals; and, accordingly, he has employed much ingenuity to show, that all these phenomena may be accounted for by experience, or by the influence of pleasurable or painful sensations, operating *at the moment* on the animal frame.

In opposition to this theory, it is maintained by Paley, that it is by *instinct*, that is, according to his own definition, "by a propensity prior to experience, and independent of instruction," "that the sexes of animals seek each other; that animals cherish their offspring; that the young quadruped is directed to the teat of its dam; that birds build their nest, and brood with so much patience upon their eggs; that insects, which do not sit upon their eggs, deposit them in those particular situations in which the young, when hatched, find their appropriate food; that it is instinct which carries the salmon, and some other fish, out of the sea into rivers, for the purpose of shedding their spawn in fresh water."[1]

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[1] *Biographical Memoirs*, p. 472.

[2] After relating, in the words of Valerius Maximus, the noted story of Caius Toranius, who betrayed his affectionate and excellent father to the triumvirate, Dr Paley thus proceeds:—

"Now, the question is, whether, if this story were related to the wild boy caught some years ago in the woods of Hanover, or to a savage without experience and without instruction, cut off in his infancy from all intercourse with his species, and consequently under no possible influence of example, authority, education, sympathy, or habit; whether, I say, such a one would feel, upon the relation, any degree of that *sentiment of disapprobation of Toranius's conduct* which we feel or not?

"They who maintain the existence of a moral sense, of innate maxims, of a natural conscience—that the love of virtue and hatred of vice are instinctive, or the perception of right or wrong intuitive (all of which are only different ways of expressing the same opinion), affirm that he would.

"They who deny the existence of a moral sense, &c. affirm that he would not.

"And upon this issue is joined."—(*Principles of Moral and Political Philosophy*, B. I. chap. 5.)

To those who are at all acquainted with the history of this dispute, it must appear evident that the question is here completely mis-stated; and that, in the whole of Dr Paley's subsequent argument on the subject, he combats a phantom of his own imagination. The opinion which he ascribes to his antagonists has been loudly and repeatedly disavowed by all the most eminent moralists who have disputed Locke's reasonings against *innate practical principles;* and is, indeed, so very obviously absurd, that it never could have been for a moment entertained by any person in his senses.

Did it ever enter into the mind of the wildest theorist to imagine that the sense of seeing would enable a man brought up, from the moment of his birth, in utter darkness, to form a conception of light and colours? But would it not be equally rash to conclude from the extravagance of such a supposition, that the sense of seeing is not an original part of the human frame?

The above quotation from Paley forces me to remark, farther, that, in combating the supposition of a *moral sense*, he has confounded together, as *only different ways of expressing the same opinion*, a variety of systems, which are regarded by all our best philosophers, not only as essentially distinct, but as in some measure standing in opposition to each other. The system of Hutcheson, for example, is identified with that of Cudworth. But although, in this instance, the author's logical discrimination does not appear to much advantage, the sweeping censure thus bestowed on so many of our most celebrated ethical theories, has the merit of throwing a very strong light on that particular view of the subject which it is the aim of his reasonings to establish, in contradiction to them all.

[3] See the section on Instinct. Sect. XVI. of that work.

In Dr Paley's very able and convincing reasonings on these various points, he has undoubtedly approached nearer to the spirit of what has been ironically called *Scottish* philosophy,[2] than any of Mr Locke's English disciples, since the time of Dr Butler; a circumstance which, when compared with the metaphysical creed of his earlier years, reflects the greatest honour on the candour and fairness of his mind, and encourages the hope, that this philosophy, where it is equally sound, will gradually and silently work its way among sincere inquirers after truth, in spite of the strong prejudices which many of our southern neighbours still appear to entertain against it. The extravagancies of Darwin, it is probable, first opened Dr Paley's eyes to the dangerous tendency of Locke's argument against innate principles, when inculcated without due limitations.[3]

With this very faint outline of the speculations of Locke's chief successors in Scotland, prior to the close of Dr Reid's literary labours, I shall for the present finish my review of the metaphysical pursuits of the eighteenth century. The long period which has since elapsed has been too much crowded with great political events to favour the growth of abstract science in any of its branches; and of the little which appears to have been done, during this interval, in other parts of Europe, towards the advancement of true philosophy, the interrupted communication between this island and the Continent left us for many years in a state of almost total ignorance. This chasm in our information concerning foreign literature, it may not be a difficult task for younger men to supply. At my time of life it would be folly to attempt it; nor, perhaps, is any author who has himself been so frequently before the public, the fittest person to form an impartial estimate of the merits of his living contemporaries. Now, however, when peace is at length restored to the world, it may reasonably be hoped that the human mind will again resume her former career with renovated energy; and that the nineteenth century will not yield to the eighteenth in furnishing materials to those who may hereafter delight to trace the progressive improvement of their species. In the meantime, instead of indulging myself in looking forward to the future, I shall conclude this section with a few general reflections suggested by the foregoing retrospect.

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[1] Paley's *Natural Theology*, p. 324.

[2] May I take the liberty of requesting the reader to compare a few pages of Dr Paley's Section on Instinct, beginning "*I am not ignorant of the theory which resolves instinct into sensation*," &c. with some remarks made by the author of this Dissertation, in an Account of the Life and Writings of Dr Reid? See the passage in section second, beginning thus, "*In a very original work, on which I have already hazarded some criticisms*," &c. As both publications appeared about the same time (in the year 1802), the coincidence, in point of thought, must have been wholly accidental, and as such affords no slight presumption in favour of its soundness.

[3] When Dr Paley published his *Principles of Moral and Political Philosophy*, he seems to have attached himself much too slavishly to the opinions of Bishop Law, to whom that work is inscribed. Hence, probably, his anxiety to disprove the existence of the moral faculty. Of the length to which Law was disposed to carry Locke's argument against innate principles, he has enabled us to judge by his own explicit declaration: "I take implanted *senses, instincts, appetites, passions, and affections*, &c. to be a remnant of the old philosophy, which used to call every thing *innate* that it could not account for; and therefore heartily wish, that they were in one sense all eradicated, which was undoubtedly the aim of that great author last mentioned (Mr Locke), as it was a natural consequence of his first book."—(Law's Translation of Archbishop King *On the Origin of Evil*, p. 79, note.)

In justice, however, to Dr Law, it must be observed, that he appears to have been fully aware that the dispute about innate principles was in a great measure verbal. "It will really," says he, "come to the same thing with regard to the moral attributes of God and the nature of virtue and vice, whether the Deity has *implanted* these instincts and affections in us, or has framed and disposed us in such a manner, has given us such powers, and placed us in such circumstances, that we must *necessarily acquire them*."—*(Ibid.)* But if Dr Law was aware of this, why should he and his followers have attached such infinite importance to the controversy?

Among these reflections, what chiefly strikes my own mind is the extraordinary change which has gradually and insensibly taken place since the publication of Locke's *Essay*, in the meaning of the word *Metaphysics;* a word formerly appropriated to the ontology and pneumatology of the schools, but now understood as equally applicable to all those inquiries, which have for their object to trace the various branches of human knowledge to their first principles in the constitution of our nature.[1] This change can be accounted for only by a change in the philosophical pursuits of Locke's successors; a change from the idle abstractions and subtleties of the dark ages, to studies subservient to the culture of the understanding; to the successful exercise of its faculties and powers; and to a knowledge of the great ends and purposes of our being. It may be regarded, therefore, as a palpable and incontrovertible proof of a corresponding progress of reason in this part of the world.

On comparing together the multifarious studies now classed together under the title of Metaphysics, it will be found difficult to trace any common circumstance but this, that they all require the same sort of mental exertion for their prosecution; the exercise, I mean, of that power (called by Locke *Reflection)* by which the mind turns its attention inwards upon its own operations, and the subjects of its own consciousness. In researches concerning our intellectual and active powers, the mind directs its attention to the faculties which it exercises, or to the propensities which put these faculties in motion. In all the other inquiries which fall under the province of the Metaphysician, the materials of his reasoning are drawn chiefly from his own internal resources. Nor is this observation less applicable to speculations which relate to things external, than to such as are confined to the thinking and sentient principle within him. In carrying on his researches (for example) concerning hardness, softness, figure, and motion, he finds it not less necessary to retire within himself, than in studying the laws of imagination or memory. Indeed, in such cases, the whole aim of his studies is to obtain a more precise definition of his *ideas*, and to ascertain the occasions on which they are formed.

From this account of the nature and object of metaphysical science, it may be reasonably expected, that those with whom it is a favourite and habitual pursuit, should acquire a more than ordinary capacity of retiring, at pleasure, from the external to the internal world. They may be expected also to acquire a disposition to examine the origin of whatsoever combinations they may find established in the fancy, and a superiority to the casual associations which warp common understandings. Hence an accuracy and a subtlety in their distinctions on all subjects, and those peculiarities in their views which are characteristical of unbiassed and original thinking. But, perhaps, the most valuable fruit of their researches, is that scrupulous precision in the use of language, upon which, more than upon any one circumstance whatever, the logical accuracy of our reasonings, and the justness of our conclusions, essentially depend. Accordingly it will be found, on a review of the history of the moral sciences, that the most important steps which have been made in some of those, apparently the most remote from metaphysical pursuits (in the science, for example, of political economy), have been made by men trained to the exercise of their intellectual powers by early habits of abstract meditation. To this fact Burke probably alluded, when he remarked, that "by turning the soul inward on itself, its forces are concentered, and are fitted for stronger and bolder flights of science; and that in such pursuits, whether we take, or whether we lose the game, the chase is certainly of service." The names of Locke, of Berkeley, of Hume, of Quesnai, of Turgot, of Morellet, and above all, of Adam Smith, will at once illustrate the truth of these observations, and show, that, in combining together, in this Dissertation, the sciences of Metaphysics, of Ethics, and of Politics, I have not adopted an arrangement altogether capricious.[1]

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[1] The following is the account of Metaphysics given by Hobbes:—" There is a certain *Philosophia prima*, on which all other Philosophy ought to depend; and consisteth principally in right limiting of the significations of such appellations, or names, as are of all others the most universal: which limitations serve to avoid ambiguity and equivocation in reasoning, and are commonly called Definitions; such as are the Definitions of Body, Time, Place, Matter, Form, Essence, Subject, Substance, Accident, Power, Act, Finite, Infinite, Quantity, Quality, Motion, Action, Passion, and divers others, necessary to the explaining of a man's conceptions concerning the nature and generation of bodies. The explication (that is, the settling of the meaning) of which, and the like terms, is commonly in the schools called *Metaphysics*."—*(Moral and Political Works.* Folio Edit. London, 1750, p. 399.)

In farther justification of this arrangement, I might appeal to the popular prejudices so industriously fostered by many, against these three branches of knowledge, as ramifications from one common and most pernicious root. How often have Mr Smith's reasonings in favour of the freedom of trade been ridiculed as *metaphysical* and visionary! Nay, but a few years have elapsed, since this epithet (accompanied with the still more opprobrious terms of Atheistical and Democratical) was applied to the argument then urged against the morality and policy of the slave-trade; and, in general, to every speculation in which any appeal was made to the beneficent arrangements of nature, or to the progressive improvement of the human race. Absurd as this language was, it could not, for a moment, have obtained any currency with the multitude, had there not been an obvious connection between these liberal doctrines, and the well known habits of logical thinking, which so eminently distinguished their authors and advocates. Whatever praise, therefore, may be due to the fathers of the modern science of political economy, belongs, at least in part (according to the acknowledgment of their most decided adversaries), to those abstract studies by which they were prepared for an analytical investigation of its first and fundamental principles.

Other connections and affinities between Political Economy and the Philosophy of the Human Mind will present themselves afterwards. At present I purposely confine myself to that which is most obvious and indisputable.

The influence of metaphysical studies may be also perceived in the philosophical spirit so largely infused into the best historical compositions of the last century. This spirit has, indeed, been often perverted to pernicious purposes; but who can doubt, that, on the whole, both history and philosophy have gained infinitely by the alliance?

How far a similar alliance has been advantageous to our poetry, may be more reasonably questioned. But on the most unfavourable supposition it must be admitted, that the number of poetical readers has thereby been greatly increased, and the pleasures of imagination proportionally communicated to a wider circle. The same remark may be extended to the study of philosophical criticism. If it has not contributed to the encouragement of original genius in the fine arts, it has been followed by a much more beneficial result in diffusing a relish for the beautiful and the elegant; not to mention its influence in correcting and fixing the public taste, by the precision and steadiness of the principles to which it appeals.[2]

Another instance, still more important, of the practical influence of metaphysical science, is the improvement which, since the time of Locke, has become general in the conduct of education, both private and public. In the former case, the fact is universally acknowledged. But even in our universities (notwithstanding the proverbial aversion of most of them to everything which savours of innovation) what a change has been gradually accomplished since the beginning of the eighteenth century! The studies of Ontology, of Pneumatology, and of Dialectics, have been supplanted by that of the Human Mind, conducted with more or less success, on the plan of Locke's *Essay;* and, in a few seats of learning, by the studies of Bacon's Method of Inquiry, of the Principles of Philosophical Criticism, and of the Elements of Political Economy. In all this an approach has been made or attempted, to what Locke so earnestly recommended to parents, " that their children's time should be spent in acquiring what may be useful to them when they come to be men." Many other circumstances, no doubt, have contributed their share in producing this revolution; but what individual can be compared to Locke in giving the first impulse to that spirit of reform by which it has been established?[1]

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[1] It furnishes no objection to these remarks, that some of our best treatises on questions of political economy have proceeded from men who were strangers to metaphysical studies. It is enough for my purpose if it be granted, that it was by habits of metaphysical thinking that the minds of those authors were formed, by whom political economy was first exalted to the dignity of a science. To a great proportion even of the learned, the rules of a sound logic are best taught by examples; and when a precise and well-defined phraseology is once introduced, the speculations of the most ordinary writers assume an appearance (sometimes, it must be owned, a very fallacious one) of depth and consistency.

Fontenelle remarks, that a single great man is sufficient to accomplish a change in the taste of his age, and that the perspicuity and method for which Descartes was indebted to his mathematical researches, were successfully copied by many of his contemporaries who were ignorant of mathematics. A similar observation will be found to apply, with still greater force, to the models of metaphysical analysis and of logical discussion, exhibited in the political works of Hume and of Smith.

[2] See some admirable remarks on this subject by Gray, in his comments on the *Io* of Plato. (Edition of *Gray*, by MATHIAS.)

In consequence of the operation of these causes, a sensible change has taken place in the style of English composition.[2] The number of idiomatical phrases has been abridged; and the language has assumed a form more systematic, precise, and luminous. The transitions, too, in our best authors, have become more logical, and less dependent on fanciful or verbal associations. If by these means our native tongue has been rendered more unfit for some of the lighter species of writing, it has certainly gained immensely as an instrument of thought, and as a vehicle of knowledge. May I not also add, that the study of it has been greatly facilitated to foreigners; and that in proportion to its rejection of colloquial anomalies, more durable materials are supplied to the present generation for transmitting their intellectual acquisitions to posterity?

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[1] Under this head of education may also be mentioned the practical improvements which, during the course of the last century, have taken place in what Lord Bacon calls *the traditive part of logic.* I allude here not only to the new arrangements in the Lancasterian Schools, by which the diffusion of the art of reading among the poorer classes of the community is so wonderfully facilitated and extended, but to those admirable elementary works which have opened a ready and speedy access to the more recondite truths of the severer sciences. How much these have contributed to promote the progress of mathematical knowledge in France may be judged of from an assertion of Condorcet, that two years spent under an able teacher now carry the student beyond the conclusions which limited the researches of Leibnitz and of Newton. The Essays lately published on this subject by M. Lacroix (*Essais sur l'Enseignement en Général, et sur celui des Mathématiques en particulier.* Paris, 1805) contain many valuable suggestions; and, beside their utility to those who are concerned in the task of instruction, may justly be considered as an accession to the Philosophy of the Human Mind.

[2] See some judicious remarks on this subject, in Mr Godwin's *Inquirer*, p. 274. In the opinion of this author, " the English language is now written with more grammatical propriety than by the best of our ancestors; and with a much higher degree of energy and vigour. The spirit of philosophy has infused itself into the structure of our sentences." He remarks farther, in favour of the present style of English composition, " that it at once satisfies the understanding and the ear." The union of these two excellencies certainly constitutes the perfection of writing. Johnson boasts, and with truth, in the concluding paper of the *Rambler*, that he had " added something to our language in the elegance of its construction, and something in the harmony of its cadence;" but what a sacrifice did he make to these objects, of conciseness, of simplicity, and of (what he has himself called) *Genuine Anglicism.* To accomplish the same ends, without any sacrifice of these higher merits, has been one of the chief aims of the most eminent among his successors.

As an instrument of thought and a medium of scientific communication, the English language appears to me, in its present state, to be far superior to the French. Diderot, indeed (a very high authority), has, with much confidence, asserted the contrary; and it is but fair to let him speak for himself: " J'ajouterois volontiers que la marche didactique et reglée à laquelle notre langue est assujettie la rend plus propre aux sciences; et que par les tours et les inversions que le Grec, le Latin, l'Italien, l'Anglois, se permettent, ces langues sont plus avantageuses pour les lettres: Que nous pouvons mieux qu' aucun autre peuple faire parler l'esprit; et que le bon sens choisiroit la langue Françoise; mais que l'Imagination et les passions donneroient la préférence aux langues anciennes et à celles de nos voisins: Qu'il faut parler François dans la société et dans les écoles de Philosophie; et Grec, Latin, Anglois, dans les chaires et sur le Théâtre: Que notre langue seroit celle de la vérité, si jamais elle revient sur la terre; et que la Grecque, la Latine, et les autres seroient les langues de la fable et du mensonge. Le François est fait pour instruire, éclairer, et convaincre; le Grec, le Latin, l'Italien, l'Anglois, pour persuader, émouvoir, et tromper; parlez Grec, Latin, Italien au peuple, mais parlez François au sage."—(*Œuvres de Diderot*, Tome II. pp. 70, 71. Amsterdam, 1772.)

These peculiar excellencies of the French language are ascribed, in part, by Diderot, to the study of the Aristotelian Philosophy.—(*Ibid.* p. 7.) I do not well see what advantage France should, in this respect, have enjoyed over England; and since that philosophy fell into disrepute, it will scarcely be alleged that the habits of thinking cultivated by Locke's disciples have been less favourable to a logical rigour of expression than those of any contemporary sect of French metaphysicians.

A later French writer has, with far greater justice, acknowledged the important services rendered to the French language, by the gentlemen of the Port Royal Society. " L'Ecole de Port Royal, féconde en penseurs, illustrée par les écrivains les plus purs, par les érudits les plus laborieux du siècle de Louis XIV. eût déja rendu parmi nous un assez grand service à la philosophie par cela seul qu'elle a puissament concouru à fixer notre langue, à lui donner ce caractére de précision, de clarté, d'exactitude, qui la rend si favorable aux opérations de l'esprit."—*Hist. Comparée*, &c. Tome II. p. 45.)

Mr Gibbon also has remarked, how much " the learned Society of Port Royal contributed to establish in France a taste for just reasoning, simplicity of style, and philosophical method." The improvement, in all these respects, of our English writers, during the same period, is, in my opinion, much more remarkable.

But granting the truth of these reflections, it may still be asked, what is the amount of the discoveries brought to light by the metaphysical speculations of the eighteenth century? Or rather, where are the principles to be found, of which it can be justly said, that they unite the suffrages, not of the *whole*, but even of the *majority* of our present philosophers? The question has been lately put and urged, with no common ability, by a foreign academician.

"The diversity of doctrines (says M. de Bonald) has increased, from age to age, with the number of masters, and with the progress of knowledge; and Europe, which at present possesses libraries filled with philosophical works, and which reckons up almost as many philosophers as writers; poor in the midst of so much riches, and uncertain, with the aid of all its guides, which road it should follow; Europe, the centre and the focus of all the lights of the world, has yet its *philosophy* only in expectation."[1]

In proof of this assertion, the author appeals to the *Comparative History of Philosophical Systems relative to the Principles of Human Knowledge*, by M. Degerando; and after a variety of acute strictures on the contradictory systems there described, sums up his argument in the following words:

"Thus, the *Comparative History of Philosophical Systems* is nothing else than a *History of the Variations* of philosophical schools, leaving no other impression upon the reader than an insurmountable disgust at all philosophical researches; and a demonstrated conviction of the impossibility of raising an edifice on *a soil so void of consistency, and so completely surrounded by the most frightful precipices.* About what then are philosophers agreed? What single point have they placed beyond the reach of dispute? Plato and Aristotle inquired, What is science? What is knowledge? And we, so many ages after these fathers of philosophy; we, so proud of the progress of human reason, still continue to repeat the same questions; vainly pursuing the same phantoms which the Greeks pursued two thousand years ago."[2]

In reply to this bold attack on the evidence of the moral sciences, it may suffice to recal to our recollection the state of physical science not more than two centuries ago. The argument of M. de Bonald against the former is, in fact, precisely the same with that ascribed by Xenophon to Socrates against those studies which have immortalised the names of Boyle and Newton; and which, in our own times, have revealed to us all the wonders of the modern chemistry. Whatever contradictions, therefore, may yet exist in our metaphysical doctrines (and of these contradictions many more than is commonly suspected will be found to be merely verbal), why should we despair of the success of future ages in tracing the laws of the intellectual world, which, though less obvious than those of the material world, are not less the natural and legitimate objects of human curiosity?

Nor is it at all wonderful that the beneficial effects of metaphysical habits of thinking should have been first perceived in political economy, and some other sciences to which, on a superficial view, they may seem to have a very remote relation; and that the rise of the sap in the tree of knowledge should be indicated by the germs at the extremities of the branches, before any visible change is discernible in the trunk. The sciences, whose improvement during the last century has been generally acknowledged, are those which are most open to common observation; while the changes which have taken place in the state of metaphysics, have attracted the notice of the few alone who take a deep interest in these abstract pursuits. The swelling of the buds, however, affords a sufficient proof that the roots are sound, and encourages the hope that the growth of the trunk, though more slow, will, in process of time, be equally conspicuous with that of the leaves and blossoms.

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[1] *Recherches Philosophiques*, &c. p. 2. Paris, 1818.

[2] *Ibid.* pp. 58, 59.

On the other hand, may it not be asked, if the number of philosophical systems be greater than that of the sects which at present divide the Christian church? The allusion here made to Bossuet's celebrated *History of the Variations*, shows plainly, that the similarity of the two cases had not been overlooked by the ingenious writer; and that the only effectual remedy which, in his opinion, can be applied to either, is to subject once more the reason, both of philosophers and of divines, to the paramount authority of an infallible guide. The conclusion is such as might have been expected from a good Catholic; but I trust that, in this country, it is not likely to mislead many of my readers. Some recent conversions to Popery, however, which, in consequence of views similar to those of M. de Bonald, have taken place among the philosophers of Germany, afford a proof that, in the present political state of Europe, the danger of a temporary relapse into the suqerstitions of the Church of Rome, how slight soever, ought not to be regarded as altogether visionary.—(See *Lectures on the History of Literature*, by FREDERICK SCHLEGEL, Vol. II. pp. 65, 88, 89, 175, 187. English Translation. Edinburgh.)

I shall close this part of my Dissertation with remarking, that the practical influence of such speculations as those of Locke and of Bacon is to be traced only by comparing, on a large scale, the state of the human mind at distant periods. Both these philosophers appear to have been fully aware (and I know of no philosopher before them of whom the same thing can be said), that the progressive improvement of the species is to be expected less from the culture of the *reasoning powers*, strictly so called, than from the prevention, in early life, of those artificial impressions and associations, by means of which, when once rivetted by habit, the strongest reason may be held in perpetual bondage. These impressions and associations may be likened to the slender threads which fastened Gulliver to the earth; and they are to be overcome, not by a sudden exertion of intellectual force, but by the gradual effect of good education, in breaking them asunder one by one. Since the revival of letters, seconded by the invention of printing, and by the Protestant Reformation, this process has been incessantly going on, all over the Christian world; but it is chiefly in the course of the last century that the result has become visible to common observers. How many are the threads which, even in Catholic countries, have been broken by the writings of Locke! How many still remain to be broken, before the mind of man can recover that moral liberty which, at some future period, it seems destined to enjoy!

NOTES AND ILLUSTRATIONS.

The chief purpose of these Notes and Illustrations, is to verify some of the more important views contained in the foregoing Historical Sketch. The errors into which I have frequently been led by trusting to the information of writers, who, in describing philosophical systems, profess to give merely the general results of their researches, unauthenticated by particular references to the original sources, have long convinced me of the propriety, on such occasions, of bringing under the eye of the reader, the specific authorities on which my statements proceed. Without such a check, the most faithful historian is perpetually liable to the suspicion of accommodating facts to his favourite theories; or of unconsciously blending with the opinions he ascribes to others, the glosses of his own imagination. The quotations in the following pages, selected principally from books not now in general circulation, may, I hope, at the same time, be useful in facilitating the labours of those who shall hereafter resume the same subject, on a scale more susceptible of the minuteness of literary detail.

For a few short biographical digressions, with which I have endeavoured to give somewhat of interest and relief to the abstract and unattractive topics which occupy so great a part of my Discourse, I flatter myself that no apology is necessary; more especially, as these digressions will in general be found to throw some additional light on the philosophical or the political principles of the individuals to whom they relate.

Note A, p. 15.

Sir Thomas More, though, towards the close of his life, he became "a persecutor even unto blood, defiling with cruelties those hands which were never polluted with bribes;"[1] was, in his earlier and better days, eminently distinguished by the humanity of his temper, and the liberality of his opinions. Abundant proofs of this may be collected from his Letters to Erasmus; and from the sentiments, both religious and political, indirectly inculcated in his *Utopia*. In contempt for the ignorance and profligacy of the monks, he was not surpassed by his correspondent; and against various superstitions of the Romish church, such as the celibacy of priests, and the use of images in worship, he has expressed himself more decidedly than could well have been expected from a man placed in his circumstances. But *these* were not the whole of his merits. His ideas on Criminal Law are still quoted with respect by the advocates for a milder code than has yet been introduced into this country; and, on the subject of toleration, no modern politician has gone farther than his Utopian Legislators.

The disorders occasioned by the rapid progress of the Reformation, having completely shaken his faith in the sanguine speculations of his youth, seem at length, by alarming his fears as to the fate of existing establishments, to have unhinged his understanding, and perverted his moral feelings. The case was somewhat the same with his friend Erasmus, who, as Jortin remarks, "began in his old days to act the zealot and the missionary with an ill grace, and to maintain, that there were *certain* heretics who might be put to death as blasphemers and rioters" (pp. 428, 481). In the mind of Erasmus, other motives, it is not improbable, concurred; his biographer and apologist being forced to acknowledge, that "he was afraid lest Francis, and Charles, and Ferdinand, and George, and Henry VIII., and other persecuting princes, should suspect that he condemned their cruel conduct."—*(Ibid.* p. 481.)

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[1] Burnet.

Something, it must at the same time be observed, may be alleged in behalf of these two illustrious persons: *not*, indeed, in extenuation of their unpardonable defection from the cause of religious liberty, but of their estrangement from some of their old friends, who scrupled not to consider as apostates and traitors, all those who, while they acknowledged the expediency of ecclesiastical reform, did not approve of the violent measures employed for the accomplishment of that object. A very able and candid argument on this point may be found in Bayle, Article *Castellan*, Note Q.

Note B, p. 16.

The following short extract will serve to convey a general idea of Calvin's argument upon the subject of usury.

"Pecunia non parit pecuniam. Quid mare? quid domus, ex cujus locatione pensionem percipio? an ex tectis et parietibus argentum proprie nascitur? Sed et terra producit, et mari advehitur quod pecuniam deinde producat, et habitationis commoditas cum certa pecunia parari commutarive solet. Quod si igitur plus ex negotiatione lucri percipi possit, quam ex fundi cujusvis proventu: an feretur qui fundum sterilem fortasse colono locaverit ex quo mercedem vel proventum recipiat sibi, qui ex pecunia fructum aliquem perceperit, non feretur? et qui pecunia fundum acquirit, annon pecunia illa generat alteram annuam pecuniam? Unde vero mercatoris lucrum? Ex ipsius, inquies, diligentia atque industria. Quis dubitat pecuniam vacuam inutilem omnino esse? neque qui a me mutuam rogat, vacuam apud se habere a me acceptam cogitat. Non ergo ex pecunia illa lucrum accedit, sed ex proventu. Illæ igitur rationes subtiles quidem sunt, et speciem quandam habent, sed ubi propius expenduntur, reipsa concidunt. Nunc igitur concludo, judicandum de usuris esse, non ex particulari aliquo Scripturæ loco, sed tantum ex æquitatis regula."—*(Calvini Epistolæ.)*

Note C, p. 22.

The prevailing idea among Machiavel's contemporaries and immediate successors certainly was, that the design of the *Prince* was hostile to the rights of mankind; and that the author was either entirely unprincipled, or adapted his professed opinions to the varying circumstances of his own eventful life. The following are the words of Bodinus, born in 1530, the very year when Machiavel died; an author whose judgment will have no small weight with those who are acquainted with his political writings: "Machiavel s'est bien fort mésconté, de dire que l'éstat populaire est le meilleur:[1] et néantmoins ayant oublié sa première opinion, il a tenu en un autre lieu,[2] que pour restituer l'Italie en sa liberté, il faut qu'il n'y ait qu'un Prince; et de fait, il s'est efforcé de former un éstat le plus tyrannique du monde; et en autre lieu[3] il confesse, que l'éstat de Venice est le plus beau de tous, lequel est une pure Aristocratie, s'il en fût onques: tellement qu'il ne sçait à quoi se tenir."—*(De la République*, Liv. vi. chap. iv. Paris, 1576). In the Latin version of the above passage, the author applies to Machiavel the phrase, *Homo levissimus ac nequissimus.*

One of the earliest apologists for Machiavel was Albericus Gentilis, an Italian author of whom some account will be given afterwards. His words are these: "Machiavel, a warm panegyrist and keen asserter of democracy; born, educated, promoted under a republican government, was in the highest possible degree hostile to tyranny. The scope of his work, accordingly, is not to instruct tyrants; but, on the contrary, by disclosing their secrets to their oppressed subjects, to expose them to public view, stripped of all their trappings." He afterwards adds, that "Machiavel's real design was, under the mask of giving lessons to sovereigns, to open the eyes of the people; and that he assumed this mask in the hope of thereby securing a freer circulation to his doctrines."—(*De Legationibus*, Lib. iii. c. ix. Lond. 1585). The same idea was afterwards adopted and zealously contended for by Wicquefort, the author of a noted book entitled the *Ambassador;* and by many other writers of a later date.[1] Bayle, in his *Dictionary*, has stated ably and impartially the arguments on both sides of the question: evidently leaning, however, very decidedly, in his own opinion, to that of Machiavel's apologists.

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[1] *Discourses upon Livy.*

[2] *Prince*, Book i. c. ix.

[3] *Discourses upon Livy.*

The following passage from the excellent work of M. Simonde de Sismondi on the Literature of the South, appears to me to approach very near to the truth in the estimate it contains both of the spirit of the *Prince*, and of the character of the author. "The real object of Machiavel cannot have been to confirm upon the throne a tyrant whom he detested, and against whom he had already conspired; nor is it more probable that he had a design to expose to the people the maxims of tyranny, in order to render them odious. Universal experience made them at that time sufficiently known to all Italy; and that infernal policy which Machiavel reduced to principles, was, in the sixteenth century, practised by every government. There is rather, in his manner of treating it, a universal bitterness against mankind; a contempt of the whole human race; which makes him address them in the language to which they had debased themselves. He speaks to the interests of men, and to their selfish calculations, as if he thought it useless to appeal to their enthusiasm or to their moral feelings."

I agree perfectly with M. de Sismondi in considering the two opposite hypotheses referred to in the above extract, as alike untenable; and have only to add to his remarks, that, in writing the *Prince*, the author seems to have been more under the influence of spleen, of ill-humour, and of blasted hopes, than of any deliberate or systematical purpose, either favourable or adverse to human happiness. The prevailing sentiment in his mind probably was, *Si populus vult decipi, decipiatur.*[2]

According to this view of the subject, Machiavel's *Prince*, instead of being considered as a new system of political morality, invented by himself, ought to be regarded merely as a digest of the maxims of state policy then universally acted upon in the Italian courts. If I be not mistaken, it was in this light that the book was regarded by Lord Bacon, whose opinion concerning it being, in *one* instance, somewhat ambiguously expressed, has been supposed by several writers of note (particularly Bayle and Mr Roscoe) to have coincided with that quoted above from Albericus Gentilis. To me it appears, that the very turn of the sentence appealed to on this occasion is rather disrespectful than otherwise to Machiavel's character. "Est itaque quod gratias agamus Machiavellio et *hujusmodi scriptoribus*, qui aperte et indissimulanter proferunt, quid homines facere soleant, non quid debeant."—(*De Aug. Scient.* Lib. vii. cap. ii.) The best comment, however, on these words, is to be found in another passage of Bacon, where he has expressed his opinion of Machiavel's moral demerits in terms as strong and unequivocal as language can furnish. "Quod enim ad *malas artes* attinet; si quis Machiavellio se dederit in disciplinam; qui præcipit," &c. &c. &c. See the rest of the paragraph (*De Aug. Scient.* Lib. viii. cap. ii.) See also a passage in Book vii. chap. viii. beginning thus: "An non et hoc verum est, juvenes multo minus *Politicæ* quam *Ethicæ* auditores idoneos esse, antequam religione et doctrina de moribus et officiis plane imbuantur; ne forte judicio depravati et corrupti, in eam opinionem veniant, non esse rerum differentias morales veras et solidas, sed omnia ex utilitate.—Sic enim Machiavellio dicere placet, *Quod si contigisset Cæsarem bello superatum fuisse, Catilina ipso fuisset odiosior,*" &c. &c. After these explicit and repeated declarations of his sentiments on this point, it is hard that Bacon should have been numbered among the apologists of Machiavel, by such high authorities as Bayle, and the excellent biographer of Lorenzo de Medicis.

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[1] See in particular ROUSSEAU *Du Contrat Social*, Liv. iii. c. vi.

[2] Many traces of this misanthropic disposition occur in the historical and even in the dramatic works of Machiavel. It is very justly observed by M. de Sismondi, that "the pleasantry of his comedies is almost always mingled with gall. His laughter at the human race is but the laughter of contempt."

It has been objected to me, that in the foregoing observations on the design of the *Prince*, I have taken no notice of the author's vindication of himself and his writings, in his letter to Zenobius Buondelmontius, annexed to the old English translation of Machiavel, printed at London in 1675 and 1680. In the preface to this translation, we are told, that the letter in question "had never before been published in any language, but lurked for above eighty years in the private cabinets of his own kindred, or the descendants of his admirers in Florence, till, in the Pontificate of Urban VIII., it was procured by the Jesuits and other busy bodies, and brought to Rome with an intention to divert that wise Pope from his design of making one of Nicholas Machiavel's name and family cardinal, as (notwithstanding all their opposition) he did, not long after. When it was gotten into that city, it wanted not those who had the judgment and curiosity to copy it, and so at length came to enjoy that privilege which all rare pieces (even the sharpest libels and pasquins) challenge at that court, which is to be sold to strangers, one of which, being a gentleman of this country, brought it over with him at his return from thence in 1645, and having translated it into English, did communicate it to divers of his friends; and by means of some of them, it hath been my good fortune to be capable of making thee a present of it; and let it serve as an apology for our author and his writings, if thou thinkest he need any."

As the translation of Machiavel, from which this advertisement is copied, is still in the hands of many readers in this country, it may not be improper to mention here, that the letter in question is altogether of English fabrication; and (as far as I can learn) is quite unknown on the Continent. It is reprinted at the end of the second volume of Farneworth's Translation of Machiavel's works, 1762, with the following statement prefixed to it.[1]

"The following letter having been printed in all the editions of the old translation, it is here given to the reader, though it certainly was not written by Machiavel. It bears date in 1537, and his death is placed by all the best historians in 1530. There are, besides, in it many internal marks, which to the judicious will clearly prove it to be the work of some other writer, vainly endeavouring at the style and manner of our excellent author. The letter is indeed a spirited and judicious defence of Machiavel and his writings; but it is written in a style too inflated, and is utterly void of that elegance and precision which so much distinguish the works of the Florentine secretary."

To the author of this last translation we are farther indebted for a very curious letter of Dr Warburton's, which renders it probable that the forgery was contrived and carried into execution by the Marquis of Wharton. I shall transcribe the letter in Warburton's words.

"There is at the end of the English translation of Machiavel's works, printed in folio, 1680, a translation of a pretended letter of Machiavel to Zenobius Buondelmontius, in vindication of himself and his writings. I believe it has been generally understood to be a feigned thing, and has by some been given to Nevil, he who wrote, if I do not mistake, the *Plato Redivivus*. But many years ago, a number of the famous Marquis of Wharton's papers (the father of the Duke) were put into my hands. Amongst these was the press copy (as appeared by the printer's marks, where any page of the printed letter began and ended) of this remarkable letter in the Marquis's hand-writing, as I took it to be, compared with other papers of his. The person who intrusted me with these papers, and who I understood had given them to me, called them back out of my hands. This anecdote I communicated to the late Speaker; and, at his desire, wrote down the substance of what I have told you, in his book of the above edition.—W. GLOUCESTER."[1]

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[1] In a book published 1816, this letter is referred to without any expression of doubt as to its authenticity. See Miller's *Lectures on the Philosophy of Modern History*, Dublin, 1816, p. 17.

From a memoir read before the French Institute in July 1814, by M. Daunou,[2] it appears that some new light has been lately thrown on the writings and life of Machiavel by the discovery of some of his unpublished papers. The following particulars cannot fail to be gratifying to many of my readers.

"M. Ginguené continue son Histoire de la Littérature Italienne, et vient de communiquer à la classe l'un des articles qui vont composer le septiéme tome de cette histoire. C'est un tableau de la vie et des écrits de Nicolas Machiavel. La vie de cet écrivain célèbre est le véritable commentaire de ses livres; et jusqu'ici ce commentaire étoit resté fort incomplet. Par exemple, on se bornait à dire, que la république de Florence, dont il étoit le secrétaire, l'avoit chargé de diverses missions politiques à la cour de France, à la cour de Rome, auprès du Duc de Valentinois, auprès de l'Empereur, au camp de Pise, &c. &c. M. Ginguené le suit année par année dans toutes ses legations, il en fait connoître l'objet et les principales circonstances. Cette vie devient ainsi une partie essentielle de l'histoire de Florence, et tient même à celle des puissances qui étoient alors en relation avec cette république. On lit peu dans la collection des Œuvres de Machiavel, ses correspondances politiques, qui neanmoins offrent tous ces details et jettent un grand jour sur son caractère et sur ses intentions. Malheureusement, ce jour lui est peu favorable, et ne nous éclaire que trop sur le véritable sens dans lequel doit être pris son Traité du Prince si diversement jugé. L'une des pièces les plus curieuses et les plus décisives est une lettre qu'il ecrivit de la campagne où il s'etoit retiré après la rentrée des Médicis à Florence Il venoit d'être destitué de ses emplois; impliqué dans une conspiration contre ces princes, il avoit été incarcéré, mis à la torture, et jugé innocent, soit qu'il le fut en effet, soit que les tourmens n'eussent pu lui arracher l'aveu de sa faute. Il trace dans ce lettre le tableau de ses occupations et de ses projets, des travaux et des distractions qui remplissent ses journées. Pour sortir d'une position voisine de la misère, il sent la nécessité de rentrer en grace avec les Medicis, et n'en trouve pas de meilleur moyen que de dedier le Traité du Prince qu'il vient d'achever à Julien le Jeune, frère du Leon X., et à qui ce Pape avoit confié le gouvernement de Florence. Machiavel croit que son Traité ne peut manquer d'être agréable et utile à un prince, et surtout à un nouveau prince. Quelque tems après, il fit en effet homage de ce livre, non à Julien, mais à Laurent II. Cette lettre, qui n'est connue en Italie, que depuis peu d'années, étoit encore ignorée en France. M. Ginguené l'a traduite: il pense qu'elle ne laisse aucune incertitude sur le but et les intentions de l'auteur du Traité du Prince."—Some farther details on this subject are to be found in a subsequent memoir by the same author, read before the French Institute in July 1815.

Soon after reading the above passage in M. Daunou's *Report*, I received nearly the same information from the north of Italy. It cannot be so well expressed as in the words of the writer:—

"Pray tell Mr Stewart that there is a very remarkable letter of Machiavel's lately published, written to a private friend at the very time he was engaged in the composition of the *Prince*, and not only fixing the date of that work, but explaining in a manner disgraceful to the author, the use he made of it, in putting it into the hands of the Medicis family. The letter is besides full of character, and describes, in a very lively manner, the life he was leading when driven away from Florence. This particular letter may be read at the end of the last volume of Pignotti's *Storia della Toscana;* a book published here, but which was in all the London shops before I came away. It is to be found also with several others, which are entertaining and curious, in a new collection published at Florence in 1814, of Machiavel's public dispatches and familiar letters. By the way, I must likewise tell Mr Stewart that my late reading has suggested a slight criticism upon one expression of his with regard to Machiavel's *Prince*, where he calls it one of the "latest of his publications." The fact is, that the three great works were none of them published in his lifetime, nor for four years after his death. They appear to have been all written at the same period of his life, during the eight or ten years of leisure that were forced upon him; and I believe it may be made out from the works themselves, that the *Prince* was composed and finished first of the three, then the *Discourses*, and last of all the *History*. This and the first having been written for the Medicis family, the MSS. were in their hands, and they published them; the *Discourses* were printed by the care of some of his personal friends. If Mr Stewart wishes to have the proof of all this in detail, I can draw it out without any trouble."

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[1] In a letter from Warburton to the Reverend Mr Birch, there is the following passage:—"I told you, I think, I had several of old Lord Wharton's papers. Amongst the rest is a manuscript in his own handwriting, a pretended translation of a manuscript apologetical epistle of Machiavel's, to his friend Zenobio. It is a wonderful fine thing. There are the printer's marks on the manuscript, which makes me think it is printed. There is a postscript of Lord Wharton's to it, by which it appears this pretended translation was designed to prefix to an English edition of his works. As I know nothing of the English edition of Machiavel, I wish you would make this out, and let me know."—*(Illustrations of the Literary History of the 18th century*, intended as a sequel to the *Literary Anecdotes* by JOHN NICHOLS. Vol. II. p. 88.)

[2] *Rapport sur les Travaux de la Classe d'Histoire*, &c. 1 Juillet, 1814.

The foregoing passage will be read by many with no common interest, when it is known that it formed part of a letter from the late Francis Horner, written a very few weeks before his death. Independently of the satisfaction I feel in preserving a memorial of his kind attention to his friends, at a period when he was himself an object of such anxious solicitude to his country, I was eager to record the opinion of so perfect and accomplished a judge on a question which, for more than two centuries, has divided the learned world; and which, his profound admiration of Machiavel's genius, combined with the most unqualified detestation of Machiavel's principles, had led him to study with peculiar care. The letter is dated Pisa, December 17. 1816.

The united tribute of respect already paid by Mr Horner's political friends and his political opponents, to his short but brilliant and spotless career in public life, renders all additional eulogies on his merits as a statesman, equally feeble and superfluous. Of the extent and variety of his learning, the depth and accuracy of his scientific attainments, the classical (perhaps somewhat severe) purity of his taste, and the truly philosophical cast of his whole mind, none had better opportunities than myself to form a judgment, in the course of a friendship which commenced before he left the University, and which grew till the moment of his death. But on these rare endowments of his understanding, or the still rarer combination of virtues which shed over all his mental gifts a characteristical grace and a moral harmony, this is not the proper place to enlarge. Never certainly was more completely realized the ideal portrait so nobly imagined by the Roman poet: "A calm devotion to reason and justice, the sanctuary of the heart undefiled, and a breast glowing with inborn honour."

> Compositum jus fasque animo, sanctosque recessus
> Mentis, et incoctum generoso pectus honesto.

Note D, p. 27.

The charge of plagiarism from Bodin has been urged somewhat indelicately against Montesquieu, by a very respectable writer, the Chevalier de Filangieri. "On a cru, et l'on croit peut-être encore, que Montesquieu a parlé le premier de l'influence du climat. Cette opinion est une erreur. Avant lui, le délicat et ingénieux Fontenelle s'étoit exercé sur cet objet. Machiavel, en plusieurs endroits de ses ouvrages, parle aussi de cette influence du climat sur le physique et sur le moral des peuples. Chardin, un de ces voyageurs qui savent observer, a fait beaucoup de réflexions sur l'influence physique et moral des climats. L'Abbé Dubos a soutenu et développé les pensées de Chardin; et Bodin, qui peut-être avoit lu dans Polybe que le climat détermine les formes, la couleur, et les mœurs des peuples, en avoit deja fait, cent cinquante ans auparavant, la base de son systême, dans son livre de la République, et dans sa Méthode de l'Histoire. Avant tous ces ecrivains, l'immortel Hippocrate avoit traité fort au long cette matière dans son fameux ouvrage *de l'air, des eaux, et des lieux.* L'auteur de l'Esprit des Lois, sans citer un seul de ces philosophes, établit à son tour un systême; mais il ne fit qu'altérer les principes d'Hippocrate, et donner une plus grande extension aux idées de Dubos, de Chardin, et de Bodin. Il voulut faire croire au public qu'il avoit eu le premier quelques idées sur ce sujet; et le public l'en crut sur sa parole."—*La Science de la Législation, ouvrage traduit de l'Italien.* Paris, 1786. Tom. I. pp. 225, 226.

The enumeration here given of writers whose works are in every body's hands, might have satisfied Filangieri, that, in giving his sanction to this old theory, Montesquieu had no wish to claim to himself the praise of originality. It is surprising, that, in the foregoing list, the name of Plato should have been omitted, who concludes his fifth book, *De Legibus*, with remarking, that "all countries are not equally susceptible of the same sort of discipline; and that a wise legislator will pay a due regard to the diversity of national character, arising from the influence of climate and of soil." It is not less surprising, that the name of Charron should have been overlooked, whose observations on the moral influence of physical causes discover as much originality of thought as those of any of his successors.—See *De la Sagesse*, Livre i. chap. xxxvii.

Note E, p. 29.

Innumerable instances of Luther's credulity and superstition are to be found in a book entitled *Martini Lutheri Colloquia Mensalia, &c.* first published, according to Bayle, in 1571. The only copy of it which I have seen, is a translation from the German into the English tongue by Captain Henrie Bell. (London 1652.) This work, in which are "gathered up the fragments of the divine discourses which Luther held at his table with Philip Melanchthon, and divers other learned men," bears to have been originally collected "out of his holy mouth" by Dr Anthony Lauterbach, and to have been afterwards "digested into common-places" by Dr Aurifaber. Although not sanctioned with Luther's name, I do not know that the slightest doubts of its details have been suggested, even by such of his followers as have regretted the indiscreet communication to the public, of his unreserved *table-talk* with his confidential companions. The very accurate Seckendorff has not called in question its authenticity; but on the contrary, gives it his indirect sanction, by remarking, that it was collected with little prudence, and not less imprudently printed: "Libro *Colloquiorum Mensalium* minus quidem cautè composito et vulgato." (Bayle, article Luther, Note L.) It is very often quoted as an authority by the candid and judicious Dr Jortin.

In confirmation of what I have said of Luther's credulity, I shall transcribe, in the words of the English translator, the substance of one of Luther's *Divine Discourses*, "concerning the devil and his works." "The devil (said Luther) can transform himself into the shape of a man or a woman, and so deceiveth people; insomuch that one thinketh he lieth by a right woman, and yet is no such matter; for, as St Paul saith, the devil is strong by the child of unbelief. But inasmuch as children or devils are conceived in such sort, the same are very horrible and fearful examples. Like unto this it is also with what they call the *Nix* in the water, who draweth people unto him as maids and virgins, of whom he begetteth devils' children. The devil can also steal children away; as sometimes children within the space of six weeks after their birth are lost, and other children, called *supposititii*, or changelings, laid in their places. Of the Saxons they were called *Killcrops*.

"Eight years since," said Luther, "at *Dessau*, I did see and touch such a changed child, which was twelve years of age; he had his eyes, and all members, like another child; he did nothing but feed, and would eat as much as two clowns were able to eat. I told the Prince of Anhalt, if I were prince of that country, I would venture *homicidium* thereon, and would throw it into the river Moldaw. I admonished the people dwelling in that place devoutly to pray to God to take away the devil. The same was done accordingly, and the second year after the changeling died.

"In Saxony, near unto Halberstad, was a man that also had a *killcrop*, who sucked the mother and five other women dry, and besides devoured very much. This man was advised that he should, in his pilgrimage at Halberstad, make a promise of the *killcrop* to the Virgin Marie, and should cause him there to be rocked. This advice the man followed, and carried the changeling thither in a basket. But going over a river, being upon the bridge, another devil that was below in the river, called and said, *Killcrop! killcrop!* Then the child in the basket (which never before spoke one word), answered, Ho, ho. The devil in the water asked further, Whither art thou going? The child in the basket said, I am going towards Hocklestad to our loving mother, to be rocked. The man being much affrighted thereat, threw the child, with the basket, over the bridge into the water. Whereupon the two devils flew away together, and cried Ho, ho, ha, tumbling themselves over one another, and so vanished."—(pp. 386, 387.)

With respect to Luther's Theological Disputes with the Devil, see the passages quoted by Bayle, Art. *Luther*, Note U.

Facts of this sort, so recent in their date, and connected with the history of so great a character, are consolatory to those who, amid the follies and extravagancies of their contemporaries, are sometimes tempted to despair of the cause of truth, and of the gradual progress of human reason.

Note F, p. 38.

Ben Jonson is one of the few contemporary writers by whom the transcendant genius of Bacon appears to have been justly appreciated; and the only one I know of, who has transmitted any idea of his forensic eloquence; a subject on which, from his own professional pursuits, combined with the reflecting and philosophical cast of his mind, Jonson was peculiarly qualified to form a competent judgment. "There happened," says he, "in my time, one noble speaker, who was full of gravity in his speaking. No man ever spoke more neatly, more pressly, more weightily, or suffered less emptiness, lest idleness in what he uttered. No member of his speech but consisted of its own graces. His hearers could not cough, or look aside from him, without loss. He commanded where he spoke, and had his judges angry and pleased at his devotion. The fear of every man that heard him was, that he should make an end." No finer description of the perfection of this art is to be found in any author, ancient or modern.

The admiration of Jonson for Bacon (whom he appears to have known intimately[1]) seems almost to have blinded him to those indelible shades in his fame, to which, even at this distance of time, it is impossible to turn the eye without feelings of sorrow and humiliation. Yet it is but candid to conclude, from the posthumous praise lavished on him by Jonson and by Sir Kenelm Digby,[2] that the servility of the courtier, and the laxity of the judge, were, in the relations of private life, redeemed by many estimable and amiable qualities. That man must surely have been marked by some rare features of moral as well as of intellectual greatness, of whom, long after his death, Jonson could write in the following words:

"My conceit of his person was never increased toward him by his place or honours; but I have and do reverence him, for the greatness that was only proper to himself, in that he seemed to me ever, by his works, one of the greatest men, and most worthy of admiration, that had been in many ages. In his adversity, I ever prayed that God would give him strength, for greatness he could not want. Neither could I condole in a word or syllable for him, as knowing no accident could do harm to virtue, but rather help to make it manifest."

In Aubrey's anecdotes of Bacon,[3] there are several particulars not unworthy of the attention of his future biographers. *One* expression of this writer is more peculiarly striking: "In short, all that were *great and good* loved and honoured him." When it is considered, that Aubrey's knowledge of Bacon was derived chiefly through the medium of Hobbes, who had lived in habits of the most intimate friendship with both, and whose writings shew that he was far from being an idolatrous admirer of Bacon's philosophy, it seems impossible for a candid mind, after reading the foregoing short but comprehensive eulogy, not to feel a strong inclination to dwell rather on the fair than on the dark side of the Chancellor's character, and, before pronouncing an unqualified condemnation, carefully to separate the faults of the age from those of the individual.

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[1] Jonson is said to have translated into Latin great part of the books *De Augmentis Scientiarum.* Dr Warton states this (I do not know on what authority) as an undoubted fact. *Essay on the Genius and Writings of Pope.*

[2] See his letters to M. de Fermat, printed at the end of FERMAT'S *Opera Mathematica*, Tolosæ, 1679.

[3] Lately published in the extracts from the Bodleian library.

An affecting allusion of his own, in one of his greatest works, to the errors and misfortunes of his public life, if it does not atone for his faults, may, at least, have some effect in softening the asperity of our censures. " Ad literas potius quam ad aliud quicquam natus, et ad res gerendas nescio quo fato contra genium suum abreptus."—*De Aug. Scient.* L. viii. c. iii.

Even in Bacon's professional line, it is now admitted, by the best judges, that he was greatly underrated by his contemporaries. " The Queen did acknowledge," says the Earl of Essex, in a letter to Bacon himself, " you had a great wit, and an excellent gift of speech, and much other good learning. But *in law*, she rather thought you could make shew, to the utmost of your knowledge, than that you were deep."

" If it be asked," says Dr Hurd, " how the Queen came to form this conclusion, the answer is plain. It was from Mr Bacon's having a great wit, an excellent gift of speech, and much other good learning."—(HURD's *Dialogues.)*

The following testimony to Bacon's legal knowledge (pointed out to me by a learned friend) is of somewhat more weight than Queen Elizabeth's judgment against it: " What might we not have expected," says Mr Hargrave, after a high encomium on the powers displayed by Bacon in his 'Reading on *the Statute of Uses;*' " what might we not have expected from the hands of such a master, if his vast mind had not so embraced within its compass the whole field of science, as very much to detach him from professional studies !"

It was probably owing in part to his court-disgrace, that so little notice was taken of Bacon, for some time after his death, by those English writers who availed themselves, without any scruple, of the lights struck out in his works. A very remarkable example of this occurs in a curious, though now almost forgotten book (published in 1627), entitled, *An Apology or Declaration of the Power and Providence of God in the Government of the World*, by George Hakewill, D. D. Archdeacon of Surrey. It is plainly the production of an uncommonly liberal and enlightened mind; well stored with various and choice learning, collected both from ancient and modern authors. Its general aim may be guessed at from the text of Scripture prefixed to it as a motto, " Say not thou, what is the cause that the former days are better than these, for thou dost not inquire wisely concerning this;" and from the words of Ovid, so happily applied by Hakewill to the " common error touching the golden age,"

> Prisca juvent alios, ego me nunc denique natum
> Gratulor.

That the general design of the book, as well as many incidental observations contained in it, was borrowed from Bacon, there cannot, I apprehend, be a doubt; and yet I do not recollect more than one or two references (and these very slight ones) to his writings, through the whole volume. One would naturally have expected, that, in the following passage of the epistle dedicatory, the name of the late unfortunate Chancellor of England, who had died in the course of the preceding year, might have found a place along with the other *great clerks* there enumerated: " I do not believe that all regions of the world, or all ages in the same region, afford wits always alike; but *this* I think (neither is it my opinion alone, but of Scaliger, Vives, Budæus, Bodin, and other *great clerks)*, that the wits of these latter ages, being manured by industry, directed by precepts, and regulated by method, may be as capable of deep speculations, and produce as masculine and lasting births, as any of the ancienter times have done. But if we conceive them to be giants, and ourselves dwarfs; if we imagine all sciences already to have received their utmost perfection, so as we need not but translate and comment on what they have done, surely there is little hope that we should ever come near them, much less match them. The first step to enable a man to the achieving of great designs, is to be persuaded that he is able to achieve them; the next not to be persuaded, that whatsoever hath not yet been done, cannot therefore *be* done. Not any one man, or nation, or age, but rather *mankind* is it, which, in latitude of capacity, answers to the universality of things to be known." In another passage, Hakewill observes, that, "if we will speak properly and punctually, antiquity rather consists in old age, than in the infancy or youth of the world." I need scarcely add, that some of the foregoing sentences are almost literal transcripts of Bacon's words.

The philosophical fame of Bacon in his own country may be dated from the establishment of the Royal Society of London; by the founders of which, as appears from their colleague, Dr Sprat, he was held in so high estimation, that it was once proposed to prefix to the history of their labours some of Bacon's writings, as the best comment on the views with which they were undertaken. Sprat himself, and his illustrious friend Cowley, were among the number of Bacon's earliest eulogists; the latter in an Ode to the Royal Society, too well known to require any notice here; the former in a very splendid passage of his History, from which I shall borrow a few sentences, as a conclusion and ornament to this note.

"For, is it not wonderful, that he who had run through all the degrees of that profession, which usually takes up men's whole time; who had studied, and practised, and governed the common law; who had always lived in the crowd, and borne the greatest burden of civil business; should yet find leisure enough for these retired studies, to excel all those men, who separate themselves for this very purpose? He was a man of strong, clear, and powerful imaginations; his genius was searching and inimitable; and of this I need give no other proof than his style itself; which as, for the most part, it describes men's minds, as well as pictures do their bodies, so it did his above all men living. The course of it vigorous and majestical; the wit bold and familiar; the comparisons fetched out of the way, and yet the more easy:[1] In all expressing a soul equally skilled in men and nature."

NOTE G, p. 40.

The paradoxical bias of Hobbes's understanding is never so conspicuous as when he engages in physical or in mathematical discussions. On such occasions, he expresses himself with even more than his usual confidence and arrogance. Of the Royal Society *(the Virtuosi,* as he calls them, *that meet at Gresham College)* he writes thus: "Conveniant, studia conferant, experimenta faciant quantum volunt, nisi et principiis utantur meis, nihil proficient." And elsewhere: "Ad causas autem propter quas proficere ne paullum quidem potuistis nec poteritis, accedunt etiam alia, ut odium Hobbii, quia nimium libere scripserat de academiis veritatem: Nam ex eo tempore irati physici et mathematici veritatem ab eo venientem non recepturos se palam professi sunt." In his English publications, he indulges in a vein of coarse scurrility, of which his own words alone can convey any idea. "So go your ways," says he, addressing himself to Dr Wallis and Dr Seth Ward, two of the most eminent mathematicians then in England, "you uncivil ecclesiastics, inhuman divines, de-doctors of morality, unasinous colleagues, egregious pair of *Issachars,* most wretched *indices* and *vindices academiarum;* and remember Vespasian's law, *that it is unlawful to give ill language first, but civil and lawful to return it.*"

NOTE H. p. 42.

With respect to the *Leviathan,* a very curious anecdote is mentioned by Lord Clarendon. "When I returned," says he, "from Spain by Paris, Mr Hobbes frequently came to me, and told me that his book, which he would call *Leviathan*, was then printing in England, and that he received every week a sheet to correct; and thought it would be finished within a little more than a month. He added, that he knew when I read the book I would not like it; and thereupon mentioned some conclusions; upon which I asked him why he would publish such doctrines; to which, after a discourse between jest and earnest, he said, '*The truth is, I have a mind to go home.*'" In another passage, the same writer expresses himself thus:—"The review and conclusion of the *Leviathan* is, in truth, a sly address to Cromwell, that, being out of the kingdom, and so being neither conquered nor his subject, he might, by his return, submit to his government, and be bound to obey it. This review and conclusion he made short enough to hope that Cromwell might read it; where he should not only receive the pawn of his new subject's allegiance, by declaring his own obligations and obedience; but by publishing such doctrines as, being diligently infused by such a master in the art of government, might secure the people of the kingdom (over whom he had no right to command) to acquiesce and submit to his brutal power."

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[1] By the word *easy,* I presume Sprat here means the native and spontaneous growth of Bacon's own fancy, in opposition to the traditionary similes borrowed by common-place writers from their predecessors.

That there is no exaggeration or misrepresentation of facts in these passages, with the view of injuring the character of Hobbes, may be confidently presumed from the very honourable testimony which Clarendon bears, in another part of the same work, to his moral as well as intellectual merits. "Mr Hobbes," he observes, "is a man of excellent parts; of great wit; of some reading; and of somewhat more thinking; one who has spent many years in foreign parts and observations; understands the learned as well as modern languages; hath long had the reputation of a great philosopher and mathematician; and in his age hath had conversation with many worthy and extraordinary men. In a word, he is one of the most ancient acquaintance I have in the world, and of whom I have always had a great esteem, as a man, who, besides his eminent learning and knowledge, hath been always looked upon as a man of probity, and of a life free from scandal."

Note I, p. 58.

It is not easy to conceive how Descartes reconciled, to his own satisfaction, his frequent use of the word *substance*, as applied to the mind, with his favourite doctrine, that the *essence* of the mind consists in *thought*. Nothing can be well imagined more unphilosophical than this last doctrine, in whatever terms it is expressed; but to designate by the name of *substance*, what is also called *thought*, in the course of the same argument, renders the absurdity still more glaring than it would otherwise have been.

I have alluded, in the text, to the difference between the popular and the scholastic notion of *substance*. According to the latter, the word *substance* corresponds to the Greek word *οὐσια*, as employed by Aristotle to denote the first of the predicaments; in which technical sense it is said, in the language of the schools, to signify *that* which supports attributes, or which is *subject to accidents*. At a period when every person liberally educated was accustomed to this barbarous jargon, it might not appear altogether absurd to apply the term *substance* to the human soul, or even to the Deity. But, in the present times, a writer who so employs it may be assured, that, to a great majority of his readers, it will be no less puzzling than it was to Crambe, in Martinus Scriblerus, when he first heard it thus defined by his master Cornelius.[1] How extraordinary does the following sentence now sound even to a philosophical ear? and yet it is copied from a work published little more than seventy years ago, by the learned and judicious Gravesande: "Substantiæ sunt aut cogitantes, aut non cogitantes; cogitantes duas novimus,

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[1] "When he was told, a *substance* was that which was *subject to accidents*, then soldiers, quoth Crambe, are the most substantial people in the world." Let me add, that, in the list of philosophical reformers, the authors of Martinus Scriblerus ought not to be overlooked. Their happy ridicule of the scholastic Logic and Metaphysics is universally known; but few are aware of the acuteness and sagacity displayed in their allusions to some of the most vulnerable passages in Locke's Essay. In this part of the work it is commonly understood that Arbuthnot had the principal share.

Deum et mentem nostram. Duæ etiam substantiæ, quæ non cogitant, nobis notæ sunt, spatium et corpus."—*Introd. ad Phil.* § 19

The Greek word οὐσία (derived from the participle of εἰμὶ) is not liable to these objections. It obtrudes no sensible image on the fancy; and, in this respect, has a great advantage over the Latin word *substantia*. The former, in its logical acceptation, is an extension to Matter, of an idea originally derived from Mind. The latter is an extension to Mind of an idea originally derived from Matter.

Instead of defining *mind* to be a thinking *substance*, it seems much more logically correct to define it a thinking *being*. Perhaps it would be better still, to avoid, by the use of the pronoun *that*, any substantive whatever, " Mind is *that* which thinks, wills," &c.

The foregoing remarks afford me an opportunity of exemplifying what I have elsewhere observed concerning the effects which the scholastic philosophy has left on the present habits of thinking, even of those who never cultivated that branch of learning. In consequence of the stress laid on the *predicaments*, men became accustomed in their youth to imagine, that in order to know the nature of any thing, it was sufficient to know under what *predicament* or *category* it ought to be arranged; and that, till this was done, it remained to our faculties a subject merely of ignorant wonder. Hence the impotent attempt to comprehend under some common name (such as that of *substance*) the heterogeneous existences of *matter*, of *mind*, and even of *empty space;* and hence the endless disputes to which the last of these words has given rise in the Schools.

In our own times, Kant and his followers seem to have thought, that they had thrown a new and strong light on the nature of *space* and also of *time*, when they introduced the word *form (forms of the intellect)* as a common term applicable to both. Is not this to revert to the scholastic folly of verbal generalization? And is it not evident, that of things which are *unique* (such as *matter, mind, space, time)* no classification is practicable? Indeed to speak of classifying what has nothing in common with any thing else, is a contradiction in terms. It was thus that St Augustine felt, when he said, "Quid sit tempus, si nemo quærat a me, scio; si quis interroget, nescio." His idea evidently was, that, although he annexed as clear and precise a notion to the word *time*, as he could do to any object of human thought, he was unable to find any term more general, under which it could be comprehended; and, consequently, unable to give any definition, by which it might be explained.

NOTE K, p. 58.

" Les Méditations de Descartes parûrent en 1641. C'étoit, de tous ses ouvrages, celui qu'il estimoit le plus. Ce qui characterise sur tout cet ouvrage, c'est qu'il contient sa fameuse démonstration de Dieu par l'idée, démonstration si répétée depuis, adoptée par les unes, et rejettée par les autres; et *qu'il est le premier où la distinction de l'esprit et de la matière soit parfaitement développée*, car avant Descartes on n'avoit encore bien approfondi les preuves philosophiques de la spiritualité de l'âme."—*Eloge de Descartes*, par M. THOMAS. Note 20.

If the remarks in the text be correct, the characteristical merits of Descartes' *Meditations* do not consist in the novelty of the proofs contained in them of the *spirituality* of the soul (on which point Descartes has added little or nothing to what had been advanced by his predecessors), but in the clear and decisive arguments by which they expose the absurdity of attempting to explain the mental phenomena, by analogies borrowed from those of matter. Of this distinction, neither Thomas, nor Turgot, nor D'Alembert, nor Condorcet, seem to have been at all aware.

I quote from the last of these writers an additional proof of the confusion of ideas upon this point, still prevalent among the most acute logicians. " Ainsi *la spiritualité de l'âme*, n'est pas une opinion qui ait besoin de preuves, mais le résultat simple et naturel d'un analyse exacte de nos idées, et de nos facultés."—(*Vie de M. Turgot.*) Substitute for *spirituality* the word *immateriality*, and the observation becomes equally just and important.

Note L, p. 59.

The following extract from Descartes might be easily mistaken for a passage in the *Novum Organon.*

"Quoniam infantes nati sumus, et varia de rebus sensibilibus judicia prius tulimus, quam integrum nostræ rationis usum haberemus, multis præjudiciis a veri cognitione avertimur, quibus non aliter videmur posse liberari, quam si semel in vita, de iis omnibus studeamus dubitare, in quibus vel minimam incertitudinis suspicionem reperiemus.

"Quin et illa etiam, de quibus dubitabimus, utile erit habere pro falsis, ut tanto clarius, quidnam certissimum et cognitu facillimum sit, inveniamus.

"Itaque ad serio philosophandum, veritatemque omnium rerum cognoscibilium indagandam, primo omnia præjudicia sunt deponenda; sive accurate est cavendum, ne ullis ex opinionibus olim a nobis receptis fidem habeamus, nisi prius, iis ad novum examen revocatis, veras esse comperiamus."—*Princ. Phil. Pars Prima,* §§ lii. lxxv.

Notwithstanding these and various other similar coincidences, it has been asserted with some confidence, that Descartes had never read the works of Bacon. "Quelques auteurs assurent que Descartes n'avoit point lu les ouvrages de Bacon; et il nous dit lui-même dans une de ses letters, qu'il ne lut que fort tard les principaux ouvrages de Galilée."—(*Eloge de Descartes,* par Thomas.) Of the veracity of Descartes I have not the slightest doubt; and therefore I consider this last fact (however extraordinary) as completely established by his own testimony. But it would require more evidence than the assertions of those nameless writers alluded to by Thomas, to convince me that he had never looked into an author, so highly extolled as Bacon is, in the letters addressed to himself by his illustrious antagonist, Gassendi. At any rate, if this was actually the case, I cannot subscribe to the reflection subjoined to the foregoing quotation by his eloquent eulogist: "Si cela est, il faut convenir, que la gloire de Descartes en est bien plus grande."

Note M, p. 65.

From the indissoluble union between the notions of colour and extension, Dr Berkeley has drawn a curious, and, in my opinion, most illogical argument in favour of his scheme of idealism;—which, as it may throw some additional light on the phenomena in question, I shall transcribe in his own words.

"Perhaps, upon a strict inquiry, we shall not find, that even those who, from their birth, have grown up in a continued habit of seeing, are still irrevocably prejudiced on the other side, to wit, in thinking what they see to be at a distance from them. For, at this time, it seems agreed on all hands, that *colours,* which are the proper and immediate objects of sight, are not without the mind. But then, it will be said, by sight we have also the ideas of extension, and figure, and motion; all which may well be thought *without,* and at some distance from the mind, though colour should not. In answer to this, I appeal to any man's experience, whether the visible extension of any object doth not appear *as near* to him as the colour of that object; nay, whether they do not both seem to be in the same place. Is not the extension we see coloured; and is it possible for us, so much as in thought, to separate and abstract colour from extension? Now, where the extension is, there surely is the figure, and there the motion too. I speak of those which are perceived by sight."[1]

Among the multitude of arguments advanced by Berkeley, in support of his favourite theory, I do not recollect any that strikes me more with the appearance of a wilful sophism than the foregoing. It is difficult to conceive how so very acute a reasoner should not have perceived that his premises, in this instance, lead to a conclusion directly opposite to what he has drawn from them. Supposing all mankind to have an irresistible conviction of the *outness* and distance of extension and figure, it is very easy to explain, from the association of ideas, and from our early habits of inattention to the phenomena of consciousness, how the sensations of colour should appear to the imagination to be transported

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[1] *Essay toward a New Theory of Vision,* p. 255.

out of the mind. But if, according to Berkeley's doctrines, the constitution of human nature leads men to believe that extension and figure, and every other quality of the material universe, exists only within themselves, whence the ideas of *external* and of *internal;* of *remote* or of *near?* When Berkeley says, "I appeal to any man's experience, whether the visible extension of any object doth not appear *as near* to him as the colour of that object;" how much more reasonable would it have been to have stated the indisputable fact, that the colour of the object appears as *remote* as its extension and figure? Nothing, in my opinion, can afford a more conclusive proof, that the natural judgment of the mind is against the inference just quoted from Berkeley, than the problem of D'Alembert, which has given occasion to this discussion.

Note N, p. 68.

It is observed by Dr Reid, that "the system which is now generally received with regard to the mind and its operations, derives not only its spirit from Descartes, but its fundamental principles; and that, after all the improvements made by Malebranche, Locke, Berkeley, and Hume, it may still be called *the Cartesian system.*"—*Conclusion of the Inquiry into the Human Mind.*

The part of the Cartesian system here alluded to is the hypothesis, that the communication between the mind and external objects is carried on by means of *ideas* or *images;—not,* indeed, transmitted *from without* (as the Aristotelians supposed) through the channel of the senses, but nevertheless bearing a relation to the qualities perceived, analogous to that of an impression on wax to the seal by which it was stamped. In this last assumption, Aristotle and Descartes agreed perfectly; and the chief difference between them was, that Descartes palliated, or rather kept out of view, the more obvious absurdities of the old theory, by rejecting the unintelligible supposition of *intentional species,* and by substituting, instead of the word *image,* the more indefinite and ambiguous word *idea.*

But there was another and very important step made by Descartes, in restricting the ideal Theory to the *primary* qualities of matter; its *secondary* qualities (of colour, sound, smell, taste, heat, and cold) having, according to him, no more *resemblance* to the sensations by means of which they are perceived, than arbitrary sounds have to the things they denote, or the edge of a sword to the pain it may occasion. (*Princ.* Pars iv. §§ 197, 198.) To this doctrine he frequently recurs in other parts of his works.

In these modifications of the Aristotelian Theory of Perception, Locke acquiesced entirely; explicitly asserting, that "the *ideas* of *primary* qualities are resemblances of them, but that the *ideas* of secondary qualities have no resemblance to them at all."—*Essay,* B. ii. c. viii. § 15.

When pressed by Gassendi to explain how images of extension and figure can exist in an unextended mind, Descartes expresses himself thus: "Quæris quomodo existimem in me subjecto inextenso recipi posse speciem ideamve corporis quod extensum est. Respondeo nullum speciem corpoream in mente recipi, sed puram intellectionem tam rei corporeæ quam incorporeæ fieri absque ulla specie corporeæ; ad imaginationem vero, quæ non nisi de rebus corporeis esse potest, opus quidem esse specie quæ sit verum corpus, et *ad quam mens se applicet,* sed non quæ in mente recipiatur." *Responsio de iis quæ in sextam Meditationem objecta sunt,* § 4.

In this reply it is manifestly assumed as an indisputable principle, that the immediate objects of our thoughts, when we *imagine* or *conceive* the primary qualities of extension and figure, are *ideas* or *species* of these qualities; and, of consequence, are themselves extended and figured. Had it only occurred to him to apply *(mutatis mutandis)* to the perception of *primary* qualities, his own account of the perception of *secondary* qualities (that it is obtained, to wit, by the *media* of sensations more analogous to arbitrary signs, than to stamps or pictures), he might have eluded the difficulty started by Gassendi, without being reduced to the disagreeable necessity of supposing his *ideas* or *images* to exist in the brain, and not in the mind. The language of Mr Locke, it is observable, sometimes implies the one of these hypotheses, and sometimes the other.

It was plainly with the view of escaping from the dilemma proposed by Gassendi to Descartes, that Newton and Clarke were led to adopt a mode of speaking concerning perception, approaching very nearly to the language of Descartes. "Is not," says Newton, "the sensorium of animals the place where the sentient substance *is present;* and to which the sensible *species* of things are brought, through the nerves and brain, that there they may be perceived by the mind *present in that place?*" And still more confidently Dr Clarke: "Without being *present to the images* of the things perceived, the soul could not possibly perceive them. A living substance can only there perceive where it is present. Nothing can any more act or be acted upon *where* it is not present, than it can *when* it is not." The distinction between primary and secondary qualities was afterwards rejected by Berkeley, in the course of his argument against the existence of matter; but he continued to retain the language of Descartes concerning *ideas*, and to consider them as the *immediate*, or rather as the *only* objects of our thoughts, wherever the external senses are concerned. Mr Hume's notions and expressions on the subject are very nearly the same.

I thought it necessary to enter into these details, in order to show with what limitations the remark quoted from Dr Reid in the beginning of this note ought to be received. It is certainly true, that the Cartesian system may be said to form the groundwork of Locke's Theory of Perception, as well as of the sceptical conclusions deduced from it by Berkeley and Hume; but it is not the less true, that it forms also the groundwork of all that has since been done towards the substitution, in place of his scepticism, of a more solid fabric of metaphysical science.

Note O, p. 69.

After the pains taken by Descartes to ascertain the *seat* of the soul, it is surprising to find one of the most learned English divines of the seventeenth century (Dr Henry More) accusing him as an abettor of the dangerous heresy of *nullibism.* Of this heresy Dr More represents Descartes as the chief author; and, at the same time, speaks of it as so completely extravagant, that he is at a loss whether to treat it as the serious opinion of the philosopher, or as the jest of a buffoon. "The chief author and leader of the Nullibists," he tells us, "seems to have been *that pleasant wit, Renatus Descartes,* who, by his *jocular* metaphysical meditations, has luxated and distorted the rational faculties of some otherwise sober and quick-witted persons." To those who are at all acquainted with the philosophy of Descartes, it is unnecessary to observe, that, so far from being a Nullibist, he valued himself not a little on having fixed the precise *ubi* of the soul, with a degree of accuracy unthought of by any of his predecessors. As he held, however, that the soul was *unextended*, and as More happened to conceive that nothing which was unextended could have any reference to place, he seems to have thought himself entitled to impute to Descartes, in direct opposition to his own words, the latter of these opinions as well as the former. "The true notion of a spirit," according to More, "is that of an extended penetrable substance, logically and intellectually divisible, but not physically discernible into parts."

Whoever has the curiosity to look into the works of this once admired, and, in truth, very able logician, will easily discover that his alarm at the philosophy of Descartes was really occasioned, not by the scheme of *nullibism*, but by the Cartesian doctrine of the *non-extension* of mind, which More thought inconsistent with a fundamental article in his own creed—the existence of witches and apparitions. To hint at any doubt about either, or even to hold any opinion that seemed to weaken their credibility, appeared to this excellent person quite a sufficient proof of complete atheism.

The observations of More on "the true notion of a spirit" (extracted from his *Enchiridion Ethicum*) were afterwards republished in Glanville's book upon witchcraft;—a work (as I before mentioned) proceeding from the same pen with the *Scepsis Scientifica*, one of the most acute and original productions of which English philosophy had then to boast.

If some of the foregoing particulars should, at first sight, appear unworthy of attention in a historical sketch of the progress of science, I must beg leave to remind my readers, that they belong to a history of still higher importance and dignity—that of the progress of Reason, and of the Human Mind.

NOTE P, p. 70.

For an interesting sketch of the chief events in the life of Descartes, see the Notes annexed to his Eloge by Thomas; where also is to be found a very pleasing and lively portrait of his moral qualities. As for the distinguishing merits of the Cartesian philosophy, and more particularly of the Cartesian metaphysics, it was a subject peculiarly ill adapted to the pen of this amiable and eloquent, but verbose and declamatory academician.

I am doubtful, too, if Thomas has not gone too far, in the following passage, on a subject of which he was much more competent to judge than of some others which he has ventured to discuss. "L'imagination brillante de Descartes se décèle partout dans ses ouvrages; et s'il n'avoit voulu être ni géométre ni philosophe, il n'auroit tenu qu'à lui d'être le plus bel esprit de son temps." Whatever opinion may be formed on this last assertion, it will not be disputed by those who have studied Descartes, that his *philosophical* style is remarkably dry, concise, and severe. Its great merit lies in its singular precision and perspicuity;—a perspicuity, however, which does not dispense with a moment's relaxation in the reader's attention; the author seldom repeating his remarks, and hardly ever attempting to illustrate or to enforce them either by reasoning or by examples. In all these respects, his style forms a complete contrast to that of Bacon's.

In Descartes' *epistolary* compositions, indeed, ample evidences are to be found of his vivacity and fancy, as well as of his classical taste. One of the most remarkable is a letter addressed to Balzac, in which he gives his reasons for preferring Holland to all other countries, not only as a tranquil, but as an agreeable residence for a philosopher; and enters into some very engaging details concerning his own petty habits. The praise bestowed on this letter by Thomas is by no means extravagant, when he compares it to the best of Balzac's. "Je ne sçais s'il y a rien dans tout Balzac où il y ait autant d'esprit et d'agrément."

NOTE Q, p. 73.

It is an error common to by far the greater number of modern metaphysicians, to suppose that there is no medium between the innate ideas of Descartes, and the opposite theory of Gassendi. In a very ingenious and learned essay on Philosophical Prejudices, by M. Trembley,[1] I find the following sentence:—"Mais l'expérience dément ce système des idées innées, puisque la privation d'un sens emporte avec elle la privation des idées attachées à ce sens, comme l'a remarqué l'illustre auteur de *l'Essai Analytique sur les Facultés de l'Ame.*"

What are we to understand by the remark here ascribed to Mr Bonnet? Does it mean nothing more than this, that to a person born blind, no instruction can convey an idea of colours, nor to a person born deaf, of sounds? A remark of this sort surely did not need to be sanctioned by the united names of Bonnet and of Trembley: Nor, indeed, does it bear in the slightest degree on the point in dispute. The question is not about our ideas of the *material* world, but about those ideas on *metaphysical* and *moral* subjects, which may be equally imparted to the blind and to the deaf; enabling them to arrive at the knowledge of the same truths, and exciting in their minds the same moral emotions. The *signs* employed in the reasonings of these two classes of persons will of course excite by association, in their respective fancies, very different *material images;* but whence the origin of the physical and moral *notions* of which these signs are the vehicle, and for suggesting which, *all* sets of signs seem to be equally fitted? The astonishing scientific attainments of many persons, blind from their birth, and the progress lately made in the instruction of the deaf, furnish palpable and incontestible proofs of the flimsiness of this article of the Epicurean philosophy;—so completely verified is now the original and profound conclusion long ago formed by Dalgarno, "That the soul can exert her powers by the ministry of any of the senses: And, therefore, when she is deprived of her principal secretaries, the eye and the ear, then she must be contented with the service of her lackeys and scullions, the other senses; which are no less true and faithful to their mistress than the eye and the ear; but not so quick for dispatch."—(*Didascalocophus*, &c. Oxford, 1680.)

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[1] *Essai sur les Préjugés*, &c. Neuchatel, 1790.

I was once in hopes of being able to throw a still stronger light on the subject of this note, by attempting to ascertain experimentally the possibility of awakening and cultivating the dormant powers of a boy destitute of the organs both of sight and of hearing; but unexpected occurrences have disappointed my expectations.

I have just learned, that a case somewhat similar, though not quite so favourable in all its circumstances, has recently occurred in the state of Connecticut in New England; and I have the satisfaction to add, there is some probability that so rare an opportunity for philosophical observations and experiments will not be overlooked in that quarter of the world.

Note R, p. 74.

Of Gassendi's orthodoxy as a Roman Catholic divine, he has left a very curious memorial, in an inaugural discourse pronounced in 1645, before Cardinal Richelieu, when he entered on the duties of his office as Regius Professor of Mathematics at Paris. The great object of the oration is to apologise to his auditors for his having abandoned his ecclesiastical functions, to teach and cultivate the profane science of geometry. With this view, he proposes to explain and illustrate the saying of Plato, who, being questioned about the employment of the Supreme Being, answered Γεώμετρεῖν τὸν θεὸν. In the prosecution of this argument, he expresses himself thus on the doctrine of the Trinity.

"Anne proinde hoc adorandum Trinitatis mysterium habebimus rursus ut sphæram, cujus quasi centrum sit Pater Æternus, qui totius divinitatis fons, origo, principium accommodate dicitur; circumferentia Filius, in quo legitur habitare plenitudo Divinitatis; et radii centro circumferentiæque intercedentes Spiritus Sanctus, qui est Patris et Filii nexus, vinculumque mutuum? Anne potius dicendum est eminere in hoc mysterio quicquid sublime magnificumque humana geometria etiamnum requirit? Percelebre est latere eam adhuc, quam quadraturam circuli vocant; atque idcirco in eo esse, ut describat triangulum, cujus si basin ostenderit circuli ambitui æqualem, tum demum esse circulo triangulum æquale demonstrat. At in hoc mysterio augustissimo gloriosissima Personarum Trias ita infinitæ essentiæ, ipsiusque fœcunditati, tanquam circulo exæquatur, seu, ut sic loquar, et verius quidem, penitus identificatur; ut cum sit omnium, et cujusque una, atque eadem essentia, una proinde ac eadem sit immensitas, æternitas, et perfectionum plenitudo.

"Sic, cum nondum norit humana geometria trisecare angulum, dividereve, et citra accommodationem mechanicam, ostendere divisum esse in tria æqualia; habemus in hocce mysterio unam essentiam non tam trisectam, quam integram communicatam in tria æqualia supposita, quæ cum simul, sigillatimque totam individuamque possideant, sint inter se tamen realiter distincta."

The rest of the oration is composed in exactly the same taste.

The following interesting particulars of Gassendi's death are recorded by Sorbière.

"Extremam tamen horam imminentem sentiens, quod reliquum erat virium impendendum existimavit præparando ad mortem animo. Itaque significavit, ut quamprimum vocaretur Sacerdos, in cujus aurem, dum fari poterat, peccata sua effunderet......................Dein, ut nihil perfectæ Christiani militis armaturæ deesset, sacro inungi oleo efflagitavit. Ad quam cæremoniam animo attendens, cum sacerdos aures inungens pronuntiaret verba solennia, et lapsu quodam memoriæ dixisset, *Indulgeat tibi Dominus* *quidquid per odoratum peccasti*, reposuit statim æger, *imo per auditum;* adeo intentus erat rei gravissimæ, et eluendarum sordium vel minimarum cupidum se et sitibundum gerebat." SORBERI *Præfatio.*

Having mentioned in the text the avowed partiality of Gassendi for the Epicurean ethics, it is but justice to his memory to add, that his own habits were, in every respect, the reverse of those commonly imputed to this school. "Ad privatam Gassendi vitam sæpius attendens," says Sorbière, "anachoretam aliquem cernere mihi videor, qui media in urbe vitam instituit plane ad monachi severioris normam; adeo paupertatem, castitatem et obedientiam coluit; quanquam sine ullo voto tria ista vota solvisse videatur.——Abstemius erat sponte sua, ptisanam tepidam bibens pulmoni refrigerando humectandoque. Carne raro, herbis sæpius, ac macerata offa mane et vespere utebatur."—*Ibid.*

NOTE S, p. 105.

It deserves to be remarked, as a circumstance which throws considerable light on the literary history of Scotland during the latter half of the eighteenth century, that, from time immemorial, a continued intercourse had been kept up between Scotland and the Continent. To all who were destined for the profession of law, an education either at a Dutch or French university was considered as almost essential. The case was nearly the same in the profession of physic; and, even among the Scottish clergy, I have conversed, in my youth, with some old men who had studied theology in Holland or in Germany. Of our smaller country gentlemen, resident on their own estates (an order of men which, from various causes, has now, alas! totally vanished), there was scarcely one who had not enjoyed the benefit of a university education; and very few of those who could afford the expence of foreign travel, who had not visited France and Italy. Lord Monboddo somewhere mentions, to the honour of his father, that he sold part of his estate to enable himself (his eldest son) to pursue his studies at the University of Groningen. The constant influx of information and of liberality from abroad, which was thus kept up in Scotland in consequence of the ancient habits and manners of the people, may help to account for the sudden burst of genius, which to a foreigner must seem to have sprung up in this country by a sort of enchantment, soon after the Rebellion of 1745. The great step *then* made was in the art of English composition. In the mathematical sciences, where the graces of writing have no place, Scotland, in proportion to the number of its inhabitants, was never, from the time of Neper, left behind by any country in Europe; nor ought it to be forgotten, that the philosophy of Newton was publicly taught by David Gregory at Edinburgh, and by his brother James Gregory at St Andrew's, before it was able to supplant the vortices of Descartes in that very university of which Newton was a member.[1] The case was similar in every other liberal pursuit, where an ignorance of the delicacies of the English tongue was not an insuperable bar to distinction. Even in the study of eloquence, as far as it was attainable in their own vernacular idiom, some of the Scottish pleaders, about the era when the two kingdoms were united, seem ambitiously, and not altogether unsuccessfully, to have formed themselves upon models, which, in modern times, it has been commonly supposed to be more safe to admire than to imitate.[2] Of the progress made in this part of the island in Metaphysical and Ethical Studies, at a period long prior to that which is commonly considered as the commencement of our literary history, I shall afterwards have occasion to speak. At present, I shall only observe, that it was in the Scottish universities that the philosophy of Locke, as well as that of Newton, was first adopted as a branch of academical education.

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[1] For this we have the authority of Whiston, the immediate successor of Sir Isaac Newton in the Lucasian Professorship at Cambridge; and of Dr Reid, who was a nephew of the two Gregorys. "Mr Gregory had already caused several of his scholars to keep Acts, as we call them, upon several branches of the Newtonian Philosophy; while we at Cambridge, poor wretches, were ignominiously studying the fictitious hypotheses of the Cartesians."—(WHISTON's *Memoirs of his own Life.*)

"I have by me," says Dr Reid, "a *Thesis* printed at Edinburgh, 1690, by James Gregory, who was at that time Professor of Philosophy at St Andrew's, containing twenty-five positions; the first three relating to logic, and the abuse of it in the Aristotelian and Cartesian philosophy. The remaining twenty-two positions are a compend of Newton's *Principia.* This *Thesis*, as was the custom at that time in the Scottish Universities, was to be defended in a public disputation, by the candidates, previous to their taking their degree."—(HUTTON's *Mathematical Dictionary.—Supplement* by DR REID to the article *Gregory.*

[2] See a splendid eulogium in the Latin language, by Sir George Mackenzie, on the most distinguished pleaders of his time at the Scottish bar. Every allowance being made for the flattering touches of a friendly hand, his portraits can scarcely be supposed not to have borne a strong and characteristical resemblance to the originals from which they were copied.

NOTE T, p. 107.

Extract of a letter from M. Allamand to Mr Gibbon.—(See GIBBON's *Miscellaneous Works.*)

"Vous avez sans doute raison de dire que les propositions évidentes dont il s'agit, ne sont pas de simples idées, mais des jugemens. Mais ayez aussi la complaisance de reconnoître que M. Locke les alleguant en exemple d'idées qui passent pour innées, et qui ne le sont pas selon lui, s'il y a ici de la méprise, c'est lui qu'il faut relever la-dessus, et non pas moi, qui n'avois autre chose à faire qu'à refuter sa manière de raisonner contre l'innéité de ces idées ou jugemens là. D'ailleurs, Monsieur, vous remarquerez, s'il vous plait, que dans cette dispute il s'agit en effet, de savoir si certaines vérités évidentes et communes, et non pas seulement certaines idées simples, sont innées ou non. Ceux qui affirment, ne donnent guère pour exemple d'idées simples qui le soyent, que celles de Dieu, de l'unité, et de l'existence; les autres exemples sont pris de propositions completes, que vous appellez jugemens.

"Mais, dites vous, y aura-t-il donc des jugemens innés? Le jugement est il autre chose qu'un acte de nos facultés intellectuelles dans la comparison des idées? Le jugement sur les vérités évidentes, n'est il pas une simple vue de ces vérités là, un simple coup d'œil que l'esprit jette sur elles? J'accorde tout cela. *Et de grace, qu'est ce qu' idée? N'est ce pas* vue, *ou* coup d'œil, *si vous voulez?* Ceux qui définissent l'idée autrement, ne s'eloignent-ils pas visiblement du sens et de l'intention du mot? Dire que les idées sont les *espéces* des choses imprimées dans l'esprit, comme l'image de l'objet sensible est tracée dans l'œil, n'est ce pas jargonner plutôt que définir? Or c'est la faute, qu'ont fait tous les metaphysiciens, et quoique M. Locke l'ait bien sentie, il a mieux aimé se facher contre eux, et tirer contre les girouettes de la place, que s'appliquer à démêler ce galimatias. Que n'a-t-il dit, non seulement il n'y a point d'idées innées dans le sens de ces Messieurs; mais *il n'y a point d'idées du tout dans ce sens là; toute idée est un acte, une vue, un coup d'œil de l'esprit.* Dès lors demander s'il y a des idées innées, c'est demander s'il y a certaines vérités si évidentes et si communes que tout esprit non stupide puisse naturellement, sans culture et sans maître, sans discussion, sans raisonnement, les reconnoitre d'un coup d'œil, et souvent même sans s'apperçevoir qu'on jette ce coup d'œil. L'affirmative me paroit incontestable, et selon moi, la question est vuidée par là.

"Maintenant prenez garde, Monsieur, que cette maniere d'entendre l'affaire, va au but des partisans des idées innées, tout comme la leur; et par la même contredit M. Locke dans le sien. Car pourquoi voudroit on qu'il y a eu des idées innées? C'est pour en opposer la certitude et l'evidence au doute universel des sceptiques, qui est ruiné d'un seul coup, s'il y a des vérités dont la vue soit nécessaire et naturelle à l'homme. Or vous sentez, Monsieur, que je puis leur dire cela dans ma façon d'expliquer la chose, tout aussi bien que les partisans ordinaires des idées innées dans la leur. Et voilà ce que semble incommoder un peu M. Locke, qui, sans se declarer Pyrrhonien, laisse apperçevoir un peu trop de foible pour le Pyrrhonisme, et a beaucoup contribué à le nourrir dans ce siècle. A force de vouloir marquer les bornes de nos connoissances, ce qui etoit fort necessaire, il a quelquefois tout mis en bornes."

NOTE U, p. 108.

"A decisive proof of this is afforded by the allusions to Locke's doctrines in the dramatic pieces then in possession of the French stage," &c.

In a comedy of Destouches (entitled *La Fausse Agnes)*, which must have been written long before the period in question,[1] the heroine, a lively and accomplished girl, supposed to be just arrived from Paris at her father's house in Poitou, is introduced as first assuming the appearance of imbecility, in order to get rid of a disagreeable lover; and, afterwards, as pleading her own cause in a mock trial before an absurd old president and two provincial ladies, to convince them that she is in reality not out of her senses. In the course of her argument on this subject, she endeavours to astonish her judges by an ironical display of her philosophical knowledge; warning them of the extreme difficulty and nicety of the question upon which they were about to pronounce. "Vous voulez juger de moi! mais, pour juger sainement, il faut une grande étendue de connoissances; encore est il bien douteux qu'il y en ait de certaines. . . . . Avant donc que vous entrepreniez de prononcer sur mon sujet, je demande préalablement que vous examiniez avec moi nos connoissances en general, les degrès de ces connoissances, leur étendue, leur réalité; que nous convenions de ce que c'est que la vérité, et si la vérité se trouve effectivement. Après quoi nous traiterons des propositions universelles, des maximes, des propositions frivoles, et de la foiblesse, ou de la solidité de nos lumières. . . . . Quelque personnes tiennent pour vérité, que l'homme nâit avec certains principes inées, certaines notions primitives, certains caractères qui sont comme gravés dans son esprit, dès le premier instant de son existence. Pour moi, j'ai longtemps examiné ce sentiment, et j'entreprends de la combattre, de le refuter, de l'aneantir, si vous avez la patience de m'ecouter." I have transcribed but a part of this curious pleading; but, I presume, more than enough to show, that every sentence, and almost every word of it, refers to Locke's doctrines. In the second and third sentences, the titles of the principal chapters in the fourth book of his *Essay* are exactly copied. It was impossible that such a scene should have produced the slightest comic effect, unless the book alluded to had been in very general circulation among the higher orders; I might perhaps add, in much *more* general circulation than it ever obtained among that class of readers in England. At no period, certainly, since it was first published (such is the difference of national manners), could similar allusions have been made to it, or to any other work on so abstract a subject, with the slightest hope of success on the London stage. And yet D'Alembert pronounces *La Fausse Agnes* to be a piece, *pleine de mouvement et de gaieté.*

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[1] This little piece was first published in 1757, three years after the author's death, which took place in 1754, in the seventy-fourth year of his age. But we are told by D'Alembert, that from the age of sixty, he had renounced, from senti-

NOTE X, p. 110.

"Descartes asserted," says a very zealous Lockist, M. de Voltaire, "that the soul, at its coming into the body, is informed with the whole series of metaphysical notions; knowing God, infinite space, possessing all abstract ideas; in a word, completely endued with the most sublime lights, which it unhappily forgets at its issuing from the womb.

"With regard to myself," continues the same writer, "I am as little inclined as Locke could be, to fancy that, some weeks after I was conceived, I was a very learned soul; knowing at that time a thousand things which I forgot at my birth; and possessing, when in the womb (though to no manner of purpose), knowledge which I lost the instant I had occasion for it; and which I have never since been able to recover perfectly."—*Letters concerning the English Nation.* Letter 13.

Whatever inferences may be deducible from some of Descartes's expressions, or from the comments on these expressions by some who assumed the title of Cartesians, I never can persuade myself, that the system of *innate ideas*, as conceived and adopted by *him*, was meant to give any sanction to the absurdities here treated by Voltaire with such just contempt. In no part of Descartes's works, as far as I have been able to discover, is the slightest ground given for this extraordinary account of his opinions. Nor was Descartes the first person who introduced this language. Long before the date of his works, it was in common use in England; and is to be found in a *Poem* of Sir John Davis, published four years before Descartes was born.

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ments of piety, all thoughts of writing for the stage.—*(Eloge de Destouches.)* This carries the date of *all* his dramatic works, at least as far back as 1740. As for Destouches's own familiarity with the writings of Locke, it is easily accounted for by his residence in England from 1717 to 1723, where he remained, for some time after the departure of Cardinal Dubois, as *Chargé d'Affaires.* Voltaire did not visit England till 1727.

(See Sect. XXVI. of *The Immortality of the Soul.)* The title of this Section expressly asserts, That *there are innate ideas in the soul.*

In one of Descartes's letters, he enters into some explanations with respect to this part of his philosophy, which he complains had been very grossly misunderstood or misrepresented. To the following passage I have no doubt that Locke himself would have subscribed. It strikes myself as so very remarkable, that, in order to attract to it the attention of my readers, I shall submit it to their consideration in an English translation.

"When I said that the idea of God is innate in us, I never meant more than this, that Nature has endowed us with a faculty by which we may know God; but I have never either said or thought, that such ideas had an actual existence, or even that they were *species* distinct from the faculty of thinking. I will even go farther, and assert that nobody has kept at a greater distance than myself from all this trash of scholastic entities, insomuch that I could not help smiling when I read the numerous arguments which Regius has so industriously collected to show that infants have no actual knowledge of God while they remain in the womb. Although the idea of God is so imprinted on our minds, that every person has within himself the faculty of knowing him, it does not follow that there may not have been various individuals who have passed through life without ever making this idea a distinct object of apprehension; and, in truth, they who think they have an idea of a plurality of Gods, have no idea of God whatsoever."—(Cartesii, *Epist.* Pars I. Epist. xcix.)

After reading this passage from Descartes, may I request of my readers to look back to the extracts in the beginning of this note, from Voltaire's letters? A remark of Montesquieu, occasioned by some strictures hazarded by this lively but very superficial philosopher on the *Spirit of Laws*, is more peculiarly applicable to him when he ventures to pronounce judgment on metaphysical writers: "Quant à Voltaire, il a *trop d'esprit pour m'entendre ;* tous les livres qu'il lit, il les fait, après quoi il approuve ou critique ce qu'il a fait."—*(Lettre à M. l'Abbé de Guasco.)* The remark is applicable to other critics as well as to Voltaire.

The prevailing misapprehensions with respect to this, and some other principles of the Cartesian metaphysics, can only be accounted for by supposing, that the opinions of Descartes have been more frequently judged of from the glosses of his followers, than from his own works. It seems to have never been sufficiently known to his adversaries, either in France or in England, that, after his philosophy had become fashionable in Holland, a number of Dutch divines, whose opinions differed very widely from his, found it convenient to shelter their own errors under his established name; and that some of them went so far as to avail themselves of his authority in propagating tenets directly opposite to his declared sentiments. Hence a distinction of *the Cartesians* into the *genuine* and the *pseudo*-Cartesians; and hence an inconsistency in their representations of the metaphysical ideas of their master, which can only be cleared up by a reference (seldom thought of) to his own very concise and perspicuous text. (Fabricii *Bib. Gr.* lib. iii. cap. vi. p. 183. Heinecc. *El. Hist. Phil.* § cx.)

Many of the objections commonly urged against the *innate ideas* of Descartes are much more applicable to the *innate ideas* of Leibnitz, whose language concerning them is infinitely more hypothetical and unphilosophical; and sometimes approaches nearly to the enthusiastic theology of Plato and of Cudworth. Nothing in the works of Descartes bears any resemblance, in point of extravagance, to what follows: "Pulcherrima multa sunt Platonis dogmata,......esse in divina mente mundum intelligibilem, quem ego quoque vocare soleo regionem idearum; objectum sapientiæ esse *τὰ ουτως οντα,* substantias nempe simplices, quæ a me *monades* appellantur, et semel existentes semper perstant, *πρωτα δεκτικα της ζωης,* id est, Deum et Animas, et harum potissimas mentes, producta a Deo simulacra divinitatis......Porro quævis mens, ut recte Plotinus, quendam in se mundum intelligibilem continet, imo mea sententia et hunc ipsum sensibilem sibi repræsentat.......Sunt in nobis *semina eorum*, quæ discimus, ideæ nempe, et quæ inde nascuntur, æternæ veritates.......Longe ergo præferendæ sunt Platonis *notitiæ innatæ*, quas *reminiscentiæ* nomine velavit, tabulæ rasæ Aristotelis et Lockii, aliorumque recentiorum, qui εξωτερικως philosophantur."—(Leib. *Opera*, Tom. II. p. 223.)

Wild and visionary, however, as the foregoing propositions are, if the names of Gassendi and of Hobbes had been substituted instead of those of Aristotle and of Locke, I should have been disposed to subscribe implicitly to the judgment pronounced in the concluding sentence. The metaphysics of Plato, along with a considerable alloy of poetical fiction, has at least the merit of containing a large admixture of important and of ennobling truth; while that of Gassendi and of Hobbes, besides its inconsistency with facts attested, every moment, by our own consciousness, tends directly to level the rational faculties of man with the instincts of the brutes.

In the *Acta Eruditorum* for the year 1684, Leibnitz observes, that "in the case of things which we have never thought of, the *innate ideas* in our minds may be compared to the figure of Hercules in a block of marble." This seems to me to prove, that the difference between him and Locke was rather in appearance than in reality; and that, although he called those ideas *innate* which Locke was at pains to trace to sensation or to reflection, he would have readily granted, that our first knowledge of their existence was coeval with the first impressions made on our senses by external objects. That this was also the opinion of Descartes is still more evident, notwithstanding the ludicrous point of view in which Voltaire has attempted to exhibit this part of his system.

Note Y, p. 111.

Mr Locke seems to have considered this use of the word *reflection* as peculiar to himself; but it is perfectly analogous to the κινήσεις κυκλίκαι of the Greek philosophers, and to various expressions which occur in the works of John Smith of Cambridge, and of Dr Cudworth. We find it in a *Poem on the Immortality of the Soul*, by Sir John Davis, Attorney-General to Queen Elizabeth; and probably it is to be met with in English publications of a still earlier date.

All things without which round about we see,
We seek to know, and have wherewith to do;
But that whereby we reason, live, and be,
Within ourselves, we strangers are thereto.

Is it because the mind is like the eye,
Through which it gathers knowledge by degrees;
Whose rays *reflect* not, but spread outwardly;
Not seeing itself, when other things it sees?

No, doubtless; for the mind can backward cast
Upon herself her understanding light;
But she is so corrupt, and so defac'd,
As her own image doth herself affright.

As is the fable of the Lady fair,
Which for her lust was turned into a cow;
When thirsty, to a stream she did repair,
And saw herself transform'd, she wist not how:

At first she startles, then she stands amaz'd;
At last with terror she from hence doth fly,
And loathes the wat'ry glass wherein she gaz'd,
And shuns it still, although for thirst she die.

For even at first *reflection* she espies
Such strange chimeras, and such monsters there;
Such toys, such antics, and such vanities,
As she retires and shrinks for shame and fear.

I have quoted these verses, chiefly because I think it not improbable that they may have suggested to Gray the following very happy allusion in his fine Fragment *De Principiis Cogitandi*:

Qualis Hamadryadum quondam si forte sororum
Una, novos peregrans saltus, et devia rura
(Atque illam in viridi suadet procumbere ripa
Fontis pura quies, et opaci frigoris umbra);
Dum prona in latices speculi de margine pendet,
Mirata est subitam venienti occurrere Nympham
Mox eosdem, quos ipsa, artus, eadem ora gerentem
Una inferre gradus, una succedere sylvæ
Aspicit alludens; seseque agnoscit in undis:
Sic sensu interno rerum simulacra suarum
Mens ciet, et proprios observat conscia vultus.

Note Z, p. 122.

The chief attacks made in England on Locke's *Essay*, during his own lifetime, were by Edward Stillingfleet, Bishop of Worcester; John Norris,[1] Rector of Bemerton; Henry Lee, B. D.;

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[1] Of this person, who was a most ingenious and original thinker, I shall have occasion afterwards to speak.

and the Reverend Mr Lowde (author of a *Discourse concerning the Nature of Man).* Of these four writers, the first is the only one whose objections to Locke are now at all remembered in the learned world; and for this distinction, Stillingfleet is solely indebted (I speak of him here merely as a metaphysician, for in some other departments of study, his merits are universally admitted) to the particular notice which Locke has condescended to take of him, in the Notes incorporated with the later editions of his *Essay.* The only circumstance which renders these Notes worthy of preservation, is the record they furnish of Locke's forbearance and courtesy, in managing a controversy carried on, upon the other side, with so much captiousness and asperity. An Irish bishop, in a letter on this subject to Mr Molyneux, writes thus: "I read Mr Locke's letter to the Bishop of Worcester with great satisfaction, and am wholly of your opinion, that he has fairly laid the great bishop on his back, but it is with so much gentleness, as if he were afraid not only of hurting him, but even of spoiling or tumbling his clothes."

The work of Lee is entitled "*Anti-scepticism*, or Notes upon each chapter of Mr Locke's *Essay concerning Human Understanding*, with an explanation of all the particulars of which he treats, and in the same order. By Henry Lee, B. D. formerly Fellow of Emanuel College in Cambridge, now Rector of Tichmarsh in Northamptonshire."—London, 1702, in folio.

The strictures of this author, which are often acute and sometimes just, are marked throughout with a fairness and candour rarely to be met with in controversial writers. It will appear remarkable to modern critics that he lays particular stress upon the charms of Locke's style, among the other excellencies which had conspired to recommend his work to public favour. "The celebrated author of the *Essay on Human Understanding* has all the advantages desirable to recommend it to the inquisitive genius of this age; an avowed pretence to new methods of discovering truth and improving learning; an unusual coherence in the several parts of his scheme; a singular clearness in his reasonings, and *above all*, a natural elegancy of style; an unaffected beauty in his expressions; a just proportion and tuneable cadence in all his periods."—(See the *Epistle Dedicatory.)*

NOTE AA, p. 125.

For the information of some of my readers, it may be proper to observe, that the word *influx* came to be employed to denote *the action* of body and soul on each other, in consequence of a prevailing theory which supposed that this action was carried on by something intermediate (whether material or immaterial was not positively decided) *flowing* from the one substance to the other. It is in this sense that the word is understood by Leibnitz, when he states as an insurmountable objection to the theory of *influx*, that "it is impossible to conceive either material particles or immaterial qualities to pass from body to mind, or from mind to body."

Instead of the term *influx*, that of *influence* came gradually to be substituted by our English writers; but the two words were originally synonymous, and were used indiscriminately as late as the time of Sir Matthew Hale.—(See his *Primitive Origination of Mankind.)*

In Johnson's *Dictionary*, the primitive and radical meaning assigned to the word *influence* (which he considers as of French extraction) is "the power of the celestial aspects operating upon terrestrial bodies and affairs;" and in the *Encyclopædia* of Chambers, it is defined to be "a quality supposed to *flow* from the bodies of the stars, either with their heat or light, to which astrologers vainly attribute all the events which happen on the earth." To this astrological use of the word Milton had plainly a reference in that fine expression of his *L'Allegro*,

"Store of ladies whose bright eyes
"*Rain influence.*"[1]

It is a circumstance worthy of notice, that a word thus originating in the dreams of astrologers and schoolmen, should now, in our language, be appropriated almost exclusively to politics. "Thus," says Blackstone, "are the electors of one branch of the legislature secured from any undue *influence* from either of the other two, and from all external violence and compulsion; but the greatest danger is that in which themselves co-operate by the infamous practice of bribery and corruption." And again, "The crown has gradually and imperceptibly gained almost as much in *influence* as it has lost in prerogative."

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[1] The explanation of the word *influence*, given in the *Dictionary* of the French Academy, accords perfectly with the tenor of the above remarks. "Vertu qui, suivant les Astrologues, *découle* des Astres sur les corps sublunaires."

In all these cases, there will be found at bottom one common idea, the existence of some secret and mysterious connection between two things, of which connection it is conceived to be impossible or unwise to trace what Bacon calls the *latens processus*.

NOTE BB, p. 126.

After these quotations from Locke, added to those which I have already produced from the same work, the reader may judge of the injustice done to him by Leibnitz, in the first sentence of his correspondence with Clarke.

"Il semble que la religion naturelle même s'affoiblit extrémement. Plusieurs font les âmes corporelles; d'autres font Dieu lui-même corporel.

"M. Locke et ses sectateurs, *doutent* au moins, si les âmes ne sont matérielles, et naturellement perissables."

Dr Clarke, in his reply to this charge, admits that "*some* parts of Locke's writings may justly be suspected as intimating his doubts whether the soul be immaterial or no; but herein (he adds) he has been followed only by some Materialists, enemies to the mathematical principles of philosophy, and who approve little or nothing in Mr Locke's writings, but his errors."

To those who have studied with care the *whole* writings of Locke, the *errors* here alluded to will appear in a very venial light when compared with the general spirit of his philosophy. Nor can I forbear to remark farther on this occasion, that supposing Locke's *doubts* concerning the immateriality of the soul to have been as real as Clarke seems to have suspected, this very circumstance would only reflect the greater lustre on the soundness of his *logical* views concerning the proper method of studying the mind;—in the prosecution of which study, he has adhered much more systematically than either Descartes or Leibnitz to the exercise of *reflection*, as the sole medium for ascertaining the internal phenomena; describing, at the same time, these phenomena in the simplest and most rigorous terms which our language affords, and avoiding, in a far greater degree than any of his predecessors, any attempt to explain them by analogies borrowed from the perceptions of the external senses.

I before observed, that Leibnitz greatly underrated Locke as a metaphysician. It is with regret I have now to mention, that Locke has by no means done justice to the splendid talents and matchless erudition of Leibnitz. In a letter to his friend Mr Molyneux, dated in 1697, he expresses himself thus: "I see you and I agree pretty well concerning Mr Leibnitz; and this sort of fiddling makes me hardly avoid thinking that he is not that very great man as has been talked of him." And in another letter, written in the same year to the same correspondent, after referring to one of Leibnitz's Memoirs in the *Acta Eruditorum* (De Primæ Philosophiæ Emendatione), he adds, "From whence I only draw this inference, that even great parts will not master any subject without great thinking, and that even the largest minds have but narrow swallows."

Let me add, that in my quotations from English writers, I adhere scrupulously to their own phraseology, in order to bring under the eye of my readers, specimens of English composition at different periods of our history. I must request their attention to this circumstance, as some expressions in the former part of this Dissertation, which have been censured as Scotticisms, occur in extracts from authors who, in all probability, never visited this side of the Tweed.

NOTE CC, p. 131.

After studying, with all possible diligence, what Leibnitz has said of his *monads* in different parts of his works, I find myself quite incompetent to annex any precise idea to the word as he has employed it. I shall, therefore, aim at nothing more in this note, but to collect, into as small a compass as I can, some of his most intelligible attempts to explain its meaning.

"A substance is a thing capable of action. It is simple or compounded. A simple substance is that which has no parts. A compound substance is an aggregate of simple substances or of *monads*.

"Compounded substances, or bodies, are multitudes. Simple substances, lives, souls, spirits, are units.[1] Such simple substances must exist everywhere; for without simple substances there could be no compounded ones. All nature therefore is full of life."—(Tom. II. p. 32.)

"*Monads*, having no parts, are neither extended, figured, nor divisible. They are the real *atoms* of nature, or, in other words, the elements of things."—(Tom. II. p. 20.)

(It must not, however, be imagined, that the *monads* of Leibnitz have any resemblance to what are commonly called *atoms* by philosophers. On the contrary, he says expressly, that "*monads* are *not* atoms of *matter*, but atoms of *substances*;—real units, which are the first principles in the composition of things, and the last elements in the analysis of substances;—of which principles or elements, what we call *bodies* are only the *phenomena*.")—(Tom. II. pp. 53. 325.)

In another passage we are told, that "a *monad* is not a *material* but a *formal* atom, it being impossible for a thing to be at once material, and possessed of a real unity and indivisibility. It is necessary, therefore," says Leibnitz, "to revive the obsolete doctrines of *substantial forms* (the essence of which consists in *force*), separating it, however, from the various abuses to which it is liable."—(*Ibid.* p. 50.)

"Every *monad* is a living mirror, representing the universe, according to its particular point of view, and subject to as regular laws as the universe itself."

"Every *monad*, with a particular body, makes a living substance."

"The knowledge of every *soul* (*âme*) extends to infinity, and to all things; but this knowledge is confused. As a person walking on the margin of the sea, and listening to its roar, hears the noise of each individual wave of which the whole noise is made up, but without being able to distinguish one sound from another, in like manner, our confused perceptions are the result of the impressions made upon us by the whole universe. The case (he adds) is the same with each *monad*."

"As for the reasonable soul or mind (*l'esprit*), there is something in it more than in the *monads*, or even than in those souls which are simple. It is not only a mirror of the universe of created things, but an image of the Deity. Such minds are capable of reflected acts, and of conceiving what is meant by the words *I*, *substance*, *monad*, *soul*, *mind*; in a word, of conceiving *things and truths* unconnected with matter; and it is this which renders us capable of science and of demonstrative reasoning.

"What becomes of these *souls*, or *forms*, on the death of the animal? There is no alternative (replies Leibnitz) but to conclude, that not only the soul is preserved, but that the *animal also with its organical machine* continues to exist, although the destruction of its grosser parts has reduced it to a smallness as invisible to our eyes as it was before the moment of conception. Thus neither animals nor souls perish at death; nor is there such a thing as *death*, if that word be understood with rigorous and metaphysical accuracy. The soul never quits completely the body with which it is united, nor does it pass from one body into another with which it had no connection before; a *metamorphosis* takes place, but there is no *metempsychosis*.—(Tom. II. pp. 51, 52.)

On this part of the Leibnitzian system, D'Alembert remarks, that it proves nothing more than that the author had perceived better than any of his predecessors, the impossibility of forming a distinct idea of the nature of *matter*; a subject, however (D'Alembert adds), on which the theory of the monads does not seem calculated to throw much light. I would rather say (without altogether denying the justness of D'Alembert's criticism), that this theory took its rise from the author's vain desire to explain the nature of *forces;* in consequence of which he suffers himself perpetually to be led astray from those *sensible effects* which are exclusively the proper objects of *physics*, into conjectures concerning their *efficient causes*, which are altogether placed beyond the reach of our research.

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[1] "Les substances simples, les vies, les âmes, les esprits, sont des unités."

Note D D, p. 134.

The *metaphysical* argument advanced by the Leibnitzians in proof of the *law of continuity* has never appeared to me to be satisfactory. "If a body at rest (it has been said) begins, *per saltum*, to move with any finite velocity, then this body must be at the same indivisible instant in two different states, that of rest and of motion, which is impossible."[1]

As this reasoning, though it relates to a *physical fact*, is itself wholly of a *metaphysical* nature; and as the inference deduced from it has been generalised into a LAW, supposed to extend to all the various branches of human knowledge, it is not altogether foreign to our present subject briefly to consider how far it is demonstratively conclusive, in this simplest of all its possible applications.

On the above argument, then, I would remark, 1. That the ideas both of *rest* and of *motion*, as well as the more general idea conveyed by the word *state*, all of them necessarily involve the idea of *time* or *duration;* and, consequently, a body cannot be said to be in a *state* either of rest or of motion, at an *indivisible* instant. Whether the body be supposed (as in the case of motion) to *change* its place from one instant to another; or to *continue* (as in that of rest) for an instant in the same place, the idea of some finite portion of time will, on the slightest reflection, be found to enter as an essential element into our conception of the physical fact.

2. Although it certainly would imply a contradiction to suppose a body to be in two different *states* at the same instant, there does not appear to be any inconsistency in asserting that an indivisible instant may form the limit between a state of rest and a state of motion. Suppose one half of this page to be painted white, and the other black, it might, I apprehend, be said with the most rigorous propriety, that the transition from the one colour to the other was made *per saltum;* nor do I think it would be regarded as a valid objection to this phraseology, to represent it as one of its implied consequences, that the mathematical line which forms their common limit, must at once be both black and white. It seems to me quite impossible to elude the force of this reasoning, without having recourse to the existence of something intermediate between *rest* and *motion*, which does not partake of the nature of either.

Is it conceivable that a body can exist in any *state* which does not fall under one or other of the two predicaments, rest or motion? If this question should be answered in the negative, will it not follow that the transition from one of these *states* to the other must, of necessity, be made *per saltum*, and must consequently violate the supposed law of continuity? Indeed, if such a law existed, how could a body at rest *begin* to move, or a body in motion come to a state of rest?

But farther, when it is said that "it is impossible for a body to have its state changed from motion to rest, or from rest to motion, without passing through all the intermediate degrees of velocity," what are we to understand by the *intermediate degrees of velocity between rest and motion?* Is not *every* velocity, how small soever, a *finite* velocity; and does it not differ as essentially from a state of rest, as the velocity of light?

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[1] "Si toto tempore," says Father Boscovich, speaking of the Law of Continuity in the Collision of Bodies, "ante contactum subsequentis corporis superficies antecedens habuit 12 gradus velocitatis, et sequenti 9, saltu facto momentaneo ipso initio contactus; in ipso momento ea tempora dirimente debuissent habere et 12 et 9 simul, quod est absurdum. Duas enim velocitates simul habere corpus non potest."—*Theoria Phil. Nat.* &c.

Boscovich, however, it is to be observed, admits the existence of the Law of Continuity in the phenomena of Motion alone (§ 143), and rejects it altogether in things co-existent with each other (§ 142). In other cases, he says, Nature does not observe the Law of Continuity with mathematical accuracy, but only *affects it;* by which expression he seems to mean, that, where she is guilty of a *saltus*, she aims at making it as moderate as possible. The expression is certainly deficient in metaphysical precision; but it is not unworthy of attention, inasmuch as it affords a proof, that Boscovich did not (with the Leibnitzians) conceive Nature, or the Author of Nature, as obeying an *irresistible necessity* in observing or not observing the Law of Continuity.

It is observed by Mr Playfair (*Dissertation on the Progress of Mathematical and Physical Science*, Part I. Sect. iii.), that Galileo was the first who maintained the existence of the *law of continuity*, and who made use of it as a principle in his reasonings on the phenomena of motion. Mr Playfair, however, with his usual discrimination and correctness, ranks this among the *mechanical* discoveries of Galileo. Indeed, it does not appear that it was at all regarded by Galileo (as it avowedly was by Leibnitz) in the light of a metaphysical and necessary *law*, which could not by any possibility be violated in any of the phenomena of motion. It was probably first suggested to him by the diagram which he employed to *demonstrate*, or rather to *illustrate*, the uniformly accelerated motion of falling bodies;[1] and the numberless and beautiful exemplifications of the same law which occur in *pure geometry*, sufficiently account for the disposition which so many Mathematicians have shown to extend it to all those branches of physics which admit of a mathematical consideration.

My late illustrious friend, who, to his many other great and amiable qualities, added the most perfect fairness and candour in his inquiries after truth, has (in the Second Part of his *Dissertation*) expressed himself with considerably greater scepticism concerning the law of continuity, than in his *Outlines of Natural Philosophy*. In that work he pronounced the metaphysical argument, employed by Leibnitz to prove its *necessity*, "to be conclusive." (Sect. VI. § 99, b.) In the Second Part of his *Dissertation* (Sect. ii.), he writes thus on the same subject:

"Leibnitz considered this principle as known *a priori*, because, if any *saltus* were to take place, that is, if any change were to happen without the intervention of time, the thing changed must be in two different conditions at the same individual instant, which is obviously impossible. Whether this reasoning be quite satisfactory or no, the conformity of the law to the facts generally observed cannot but entitle it to great authority in judging of the explanations and theories of natural phenomena."

The phrase, *Law of Continuity*, occurs repeatedly in the course of the correspondence between Leibnitz and John Bernouilli, and appears to have been *first* used by Leibnitz himself. The following passage contains some interesting particulars concerning the history of this law: "*Lex Continuitatis*, cum usque adeo sit rationi et naturæ consentanea, et usum habeat tam late patentem, mirum tamen est eam a nemine (quantum recorder) antea adhibitam fuisse. Mentionem ejus aliquam feceram olim in Novellis Reipublicæ Literariæ (Juillet, 1687, p. 744), occasione collatiunculæ cum Malebranchio, qui ideo meis considerationibus persuasus, suam de legibus motus in Inquisitione Veritatis expositam doctrinam postea mutavit; quod brevi libello edito testatus est, in quo ingenue occasionem mutationis exponit. Sed tamen paullo promptior, quam par erat, fuit in novis legibus constituendis in eodem libello, antequam mecum communicasset; nec tantum in veritatem, sed etiam in illam ipsam Legem Continuitatis, etsi minus aperte, denuo tamen impegit; quod nolui viro optimo objicere, ne viderer ejus existimationi detrahere velle."—*Epist.* Leibnit. ad Joh Bernouilli, 1697.

From one of John Bernouilli's letters to Leibnitz, it would appear that he had himself a conviction of the truth of this law, before he had any communication with Leibnitz upon the subject.

"Placet tuum criterium pro examinandis re-

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[1] Descartes seems, from his correspondence with Mersenne, to have been much puzzled with Galileo's reasonings concerning the descent of falling bodies; and in alluding to it, has, on different occasions, expressed himself with an indecision and inconsistency of which few instances occur in his works. (Vide *Cartesii Epist.* Pars II. Epist. xxxiv. xxxv. xxxvii. xci.) His doubts on this point will appear less surprising, if compared with a passage in the article *Méchanique* in D'Alembert's *Elémens de Philosophie.* "Tous les philosophes paroissent convenir, que la vitesse avec laquelle les corps qui tombent commencent à se mouvoir est absolument nulle," &c. &c.—(See his *Melanges*, Tom. IV. p. 219, 220.)

gulis motuum, quod *legem continuitatis* vocas; est enim per se evidens, et velut a natura nobis inditum, quod evanescente inæqualitate hypothesium, evanescere quoque debeant inæqualitates eventuum. Hinc multoties non satis mirari potui, qui fieri potuerit, ut tam incongruas, tam absonas, et tam manifeste inter se pugnantes regulas, excepta sola prima, potuerit condere Cartesius, vir alias summi ingenii. Mihi videtur vel ab infante falsitatem illarum palpari posse, eo quod ubique saltus ille, naturæ adeo inimicus, manifeste nimis elucet."—*Epist.* Bernouilli ad Leib. 1696. Vide Leibnitzii et Jo. Bernouilli *Comm. Epist.* 2 vols. 4to. Lausannæ et Genevæ, 1745.)

Note E E, p. 134.

Mais il restoit encore la plus grande question, de ce que ces âmes ou ces formes deviennent par la mort de l'animal, ou par la destruction de l'individu de la substance organisé. Et c'est ce qui embarrasse le plus; d'autant qu'il paroit peu raisonnable que les âmes restent inutilement dans un chaos de matière confuse. Cela m'a fait juger enfin qu'il n'y avoit qu'un seul parti raisonnable à prendre; et c'est celui de la conservation non seulement de l'âme, mais encore de l'animal même, et de la machine organique; quoique la destruction des parties grossières l'ait reduit à une petitesse qui n'echappe pas moins à nos sens que celle où il etoit avant que de nâitre.—(Leib. *Op.* Tom. II. p. 51.)

.... Des personnes fort exactes aux expériences se sont deja aperçues de nôtre tems,[1] qu'on peut douter, si jamais un animal tout à fait nouveau est produit, et si les animaux tout en vie ne sont deja en petit avant la conception dans les semences aussi bien que les plantes. Cette doctrine etant posée, il sera raisonnable de juger, que ce qui ne commence pas de vivre ne cesse pas de vivre non plus; et que la mort, comme la generation, n'est que la transformation du même animal qui est tantôt augmenté, et tantôt diminué.—(*Ibid.* pp. 42, 43.)

.... Et puisqu' ainsi il n'y a point de première naissance ni de génération entièrement nouvelle de l'animal, il s'ensuit qu'il n'y en aura point d'extinction finale, ni de mort entière prise à la rigueur métaphysique; et que, par consequent, au lieu de la transmigration des âmes, il n'y a qu'une transformation d'un même animal, selon que les organes sont pliés différément, et plus ou moins développés.—(*Ibid.* p. 52.)

Quant à la Métempsycose, je crois que l'ordre ne l'admet point; il veut que tout soit explicable distinctement, et que rien ne se fasse par saut. Mais le passage de l'âme d'un corps dans l'autre seroit un saut étrange et inexplicable. Il se fait toujours dans l'animal ce qui se fait presentement: C'est que le corps est dans un changement continuel, comme un fleuve, et ce que nous appellons génération ou mort, n'est qu'un changement plus grand et plus prompt qu'à l'ordinaire, tel que seroit le saut ou la cataracte d'une rivière. Mais ces sauts ne sont pas absolus et tels que je désaprouve; comme seroit celui d'un corps qui iroit d'un lieu à un autre sans passer par le milieu. *Et de tels sauts ne sont pas seulement défendus dans les mouvemens, mais encore dans tout ordre des choses ou des vérités.*—The sentences which follow afford a proof of what I have elsewhere remarked, how much the mind of Leibnitz was misled, in the whole of this metaphysical theory, by habits of thinking formed in early life, amidst the hypothetical abstractions of pure geometry; a prejudice (or *idol of the* mathematical *den*) to which the most important errors of his philosophy might, without much difficulty, be traced.—Or comme dans une ligne de géométrie il y a certains points distingués, qu'on appelle sommets, points d'inflexion, points de rebroussement, ou autrement; et comme il y en a des lignes qui en ont une infinité, c'est ainsi qu'il faut concevoir dans la vie d'un animal ou d'une personne les tems d'un changement extraordinaire, qui ne laissent pas d'être dans la regle générale; de même que les points distingués dans la courbe se peuvent determiner par sa nature générale ou son équation. On peut toujours dire d'un animal *c'est*

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[1] The experiments here referred to are the observations of Swammerdam, Malpighi, and Lewenhoeck.

tout comme ici, la difference n'est que du plus ou moins."—(Tom. V. p. 18.)

Note FF, p. 136.

The praise which I have bestowed on this Memoir renders it necessary for me to take some notice of a very exceptionable proposition which is laid down in the first paragraph, as a fundamental maxim,—that "all proper names were at first appellatives;" a proposition so completely at variance with the commonly received opinions among later philosophers, that it seems an object of some curiosity to inquire, how far it is entitled to plead in its favour the authority of Leibnitz. Since the writings of Condillac and of Smith, it has, so far as I know, been universally acknowledged, that, if there be any one truth in the *Theoretical History* of Language, which we are entitled to assume as an incontrovertible fact, it is the direct contrary of the above proposition. Indeed, to assert that all proper names were at first appellatives, would appear to be nearly an absurdity of the same kind as to maintain, that *classes* of objects existed before *individual* objects had been brought into being.

When Leibnitz, however, comes to explain his idea more fully, we find it to be something very different from what his words literally imply; and to amount only to the trite and indisputable observation, that, in simple and primitive languages, all proper names (such as the names of persons, mountains, places of residence, &c.) are descriptive or significant of certain prominent and characteristical features, distinguishing them from other objects of the same class;—a fact, of which a large proportion of the surnames still in use, all over Europe, as well as the names of mountains, villages, and rivers, when traced to their primitive roots, afford numerous and well known exemplifications.

Not that the proposition, even when thus explained, can be assumed as a general maxim. It holds, indeed, in many cases, as the Celtic and the Saxon languages abundantly testify in our own island; but it is true only under certain limitations, and it is perfectly consistent with the doctrine delivered on this subject by the greater part of philologers for the last fifty years.

In the history of language, nothing is more remarkable, than the aversion of men to coin words out of unmeaning and arbitrary sounds; and their eagerness to avail themselves of the stores already in their possession, in order to give utterance to their thoughts on the new topics which the gradual extension of their experience is continually bringing within the circle of their knowledge. Hence metaphors, and other figures of speech; and hence the various changes which words undergo, in the way of amplification, diminution, composition, and the other transformations of elementary terms which fall under the notice of the etymologist. Were it not, indeed, for this strong and universal bias of our nature, the vocabulary of every language would, in process of time, become so extensive and unwieldy, as to render the acquisition of one's mother tongue a task of immense difficulty, and the acquisition of a dead or foreign tongue next to impossible. It is needless to observe, how immensely these tasks are facilitated by that etymological system which runs, more or less, through every language; and which everywhere proceeds on certain analogical principles, which it is the business of the practical grammarian to reduce to general rules, for the sake of those who wish to speak or to write it with correctness.

In attempting thus to trace backwards the steps of the mind towards the commencement of its progress, it is evident, that we must at last arrive at a set of elementary and primitive roots, of which no account can be given, but the arbitrary choice of those who first happened to employ them. It is to this *first* stage in the infancy of language that Mr Smith's remarks obviously relate; whereas the proposition of Leibnitz, which gave occasion to this note, as obviously relates to its subsequent stages, when the language is beginning to assume somewhat of a regular form, by compositions and other modifications of the materials previously collected.

From these slight hints it may be inferred, 1*st*, That the proposition of Leibnitz. although it may seem, from the very inaccurate and equivocal terms in which it is expressed, to stand in direct opposition to the doctrine of Smith, was really meant by the author to state a fact totally unconnected with the question under Smith's consideration. *2dly*, That even in the sense in which it was understood by the author, it fails entirely, when extended to that *first* stage in the infancy of language, to which the introductory paragraphs in Mr Smith's discourse are exclusively confined.

Note GG, p. 138.

"Je viens de recevoir une lettre d'un Prince Regnant de l'Empire, où S. A. me marque avoir vu deux fois ce printems à la derniere foire de Leipsig, et examiné avec soin un chien qui parle. Ce chien a prononcé distinctement plus de trente mots, repondant même assez à propos à son maître: il a aussi prononcé tout l'alphabet excepté les lettres m, n, x."—(Leib. *Opera*, Tom. V. p. 72.)

Thus far the fact rests upon the authority of the German prince alone. But from a passage in the *History of the Academy of Sciences*, for the year 1706, it appears that Leibnitz had himself seen and heard the dog. What follows is transcribed from a report of the Academy upon a letter from Leibnitz to the Abbé de St Pierre, giving the details of this extraordinary occurrence.

"Sans un garant tel que M. Leibnitz, temoin oculaire, nous n'aurions pas la hardiesse de rapporter, qu'auprès de Zeitz dans la Misnie, il y a un chien qui parle. C'est un chien de Paysan, d'une figure des plus communes, et de grandeur mediocre. Un jeune enfant lui entendit pousser quelques sons qu'il crut ressembler à des mots Allemands, et sur cela se mit en tête de lui apprendre à parler. Le maitre, qui n'avoit rien de mieux a faire, n'y épargna pas le tems ni ses peines, et heureusement le disciple avoit des dispositions qu'il eut été difficile de trouver dans un autre. Enfin, au bout de quelques années, le chien sçut prononcer environ une trentaine de mots: de ce nombre sont *Thé*, *Caffé*, *Chocolat*, *Assemblée*, mots François, qui ont passé dans l'Allemand tels qu'ils sont. Il est a remarquer, que le chien avoit bien trois ans quand il fut mis à l'école. Il ne parle que par écho, c'est a dire, après que son maître a prononcé un mot; et il semble, qu'il ne repète que par force et malgre lui, quoiqu'on ne le maltraite pas. Encore une fois, M. Leibnitz l'a vu et entendu."

(Exposé d'une lettre de M. Leibnitz à l'Abbé de St Pierre sur un chien qui parle.) "Cet exposé de la lettre de M. Leibnitz se trouve dans l'Histoire de l'Academie des Sciences, année 1706. Ce sont les Auteurs de l'Histoire de l'Académie qui parlent."—(Leib. *Opera*, Vol. II. p. 180. P. II.)

May not all the circumstances of the above story be accounted for, by supposing the master of the dog to have possessed that peculiar species of imitative power which is called *Ventriloquism?* Mathews, I have no doubt, would find little difficulty in managing such a deception, so as to impose on the senses of any person who had never before witnessed any exhibition of the same kind.

Note H H, p. 138.

When I speak in favourable terms of the *Philosophical Spirit*, I hope none of my readers will confound it with the spirit of that false philosophy, which, by unhinging every rational principle of belief, seldom fails to unite in the same characters the extremes of scepticism and of credulity. It is a very remarkable fact, that the same period of the eighteenth century, and the same part of Europe which were most distinguished by the triumphs of Atheism and Materialism, were also distinguished by a greater number of visionaries and impostors than had ever appeared before, since the revival of letters. Nor were these follies confined to persons of little education. They extended to men of the highest rank, and to many individuals of distinguished talents. Of this the most satisfactory proofs might be produced; but I have room here only for one short quotation. It is from the pen of the Duc de Levis, and relates to the celebrated Maréschal de Richelieu, on whom Voltaire has lavished so much of his flattery. "Ce dont je suis positivement certain, c'est que cet homme spirituel (Le Maréschal de Richelieu) étoit

superstitieux, et qu'il croyoit aux predictions des astrologues et autres sottises de cet espèce. Je l'ai vu refusant à Versailles d'aller faire sa cour au fils ainé de Louis XVI. en disant serieusement, *qu'il savoit* que cet enfant n'etoit point destiné au trône. Cette crédulité superstitieuse, générale pendant la ligue, étoit encore très commune sous la régence lorsque le Duc de Richelieu entra dans le monde; par la plus bizarre des inconséquences, elle s'allioit très bien avec la plus grande impiété, et la plupart des matérialistes croyoient aux *esprits;* aujourd'hui, ce genre de folie est très rare; mais beaucoup de gens, qui se moquent des astrologues, croient à des prédictions d'une autre espèce."—(*Souvenirs et Portraits*, par M. DE LEVIS, à Paris, 1813.)

Some extraordinary facts of the same kind are mentioned in the *Memoirs of the Marquis de Bouillé.* According to him, Frederic the Great himself was not free from this sort of superstition.

A similar remark is made by an ancient historian, with respect to the manners of Rome at the period of the Gothic invasion. "There are many who do not presume either to bathe, or to dine, or to appear in public, till they have diligently consulted, according to the rules of astrology, the situation of Mercury, and the aspect of the Moon. It is singular enough that this vain credulity may often be discovered among the prophane sceptics, who impiously doubt or deny the existence of a Celestial Power."—(GIBBON, from Ammianus Marcellinus, *Decline and Fall of the Roman Empire*, Vol. V. p. 278.)

NOTE I I, p. 139

The following estimate of Leibnitz, considered in comparison with his most distinguished contemporaries, approaches, on the whole, very nearly to the truth; although some doubts may be entertained about the justness of the decision in the last clause of the sentence. "Leibnitz, aussi hardi que Descartes, aussi subtil que Bayle, peut-être moins profond que Newton, et moins sage que Locke, mais seul universel entre tous ces grand hommes, paroit avoir embrassé le domaine de la raison dans toute son étendue, et avoir contribué le plus a répandre cet esprit philosophique que fait aujourd'hui la gloire de notre siècle."—(BAILLY, *Eloge de Leibnitz.*)

I have mentioned in the text only a part of the learned labours of Leibnitz. It remains to be added, that he wrote also on various subjects connected with chemistry, medicine, botany, and natural history; on the philosophy and language of the Chinese; and on numberless other topics of subordinate importance. The philological discussions and etymological collections, which occupy so large a space among his works, would (even if he had produced nothing else) have been no inconsiderable memorials of the activity and industry of his mind.

Manifold and heterogeneous as these pursuits may at first appear, it is not difficult to trace the thread by which his curiosity was led from one of them to another. I have already remarked a connection of the same sort between his different metaphysical and theological researches; and it may not be altogether uninteresting to extend the observation to some of the subjects enumerated in the foregoing paragraph.

The studies by which he first distinguished himself in the learned world (I pass over that of jurisprudence,[1] which was imposed on him by the profession for which he was destined) were directed to the antiquities of his own country; and more particularly to those connected with the history of the house of Brunswick. With this view he ransacked, with an unexampled industry, the libraries, monasteries, and other archives, both of Germany and of Italy; employing in this ungrateful drudgery several of the best and most precious years of his life. Mortified, however, to find how narrow the limits are, within which the range of written records is confined, he struck out for himself and his successors a new and unexpected light, to guide them through the seemingly hopeless darkness of remote ages. This light was the study of etymology, and of the affinities of different tongues in their primitive roots;—a light at first faint and glimmering, but which, since his time, has continued to increase in brightness, and is likely to do so more and more as the world grows older. It is pleasing to see his curiosity on this subject expand, from the names of the towns and rivers and mountains in his neighbourhood, till it reached to China and other regions in the east; leading him, in the last result, to some general conclusions concerning the origin of the different tribes of our species, approximating very nearly to those which have been since drawn from a much more extensive range of *data* by Sir William Jones, and other philologers of the same school.

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[1] Bailly, in his *Eloge on Leibnitz*, speaks of him in terms of the most enthusiastic praise, as a philosophical jurist, and as a man fitted to become the legislator of the human race. To me, I must own, it appears, that there is no part of his writings in which he discovers less of his characteristical originality, than where he professes to treat of the law of nature. On these occasions, how inferior does he appear to Grotius, not to speak of Montesquieu and his disciples !

As an additional light for illustrating the antiquities of Germany, he had recourse to natural history; examining, with a scientific eye, the shells and other marine bodies everywhere to be found in Europe, and the impressions of plants and fishes (some of them unknown in this part of the world) which are distinctly legible, even by the unlettered observer, on many of our fossils. In entering upon this research, as well as on the former, he seems to have had a view to Germany alone; on the state of which (he tells us), prior to all historical documents, it was his purpose to prefix a discourse to his History of the House of Brunswick. But his imagination soon took a bolder flight, and gave birth to his *Protogœa;*—a dissertation which (to use his own words) had for its object "to ascertain the original face of the earth, and to collect the vestiges of its earliest history from the monuments which nature herself has left of her successive operations on its surface." It is a work which, wild and extravagant as it may now be regarded, is spoken of by Buffon with much respect; and is considered by Cuvier as the ground-work of Buffon's own system on the same subject.

In the connection which I have now pointed out between the Historical, the Philological, and the Geological speculations of Leibnitz, Helvetius might have fancied that he saw a new exemplification of *the law of continuity;* but the true light in which it ought to be viewed, is as a faithful picture of a philosophical mind emancipating itself from the trammels of local and conventional details, and gradually rising from subject to subject, till it embraces in its survey those nobler inquiries which, sooner or later, will be equally interesting to every portion of the human race.[1]

Note K K, p. 143.

Of Locke's affectionate regard for Collins, notwithstanding the contrariety of their opinions on some questions of the highest moment, there exist many proofs in his letters, published by M Des Maizeaux. In one of these, the following passage is remarkable. It is dated from Oates in Essex, 1703, about a year before Locke's death.

"You complain of a great many defects; and that very complaint is the highest recommendation I could desire to make me love and esteem you, and desire your friendship. And if I were now setting out in the world, I should think it my great happiness to have such a companion as you, who had a true relish for truth; would in earnest seek it with me; from whom I might receive it undisguised; and to whom I might communicate what I thought true freely. Believe it, my good friend, to love truth for truth's sake, is the principal part of human perfection in this world, and the seed-plot of all other virtues; and, if I mistake not, you have as much of it as ever I met with in any body. What, then, is there wanting to make you equal to the best; a friend for any one to be proud of?" . . . . . . The whole of Locke's letters to Collins are highly interesting and curious; more particularly *that* which he desired to be delivered to him after his own death. From the general tenor of these letters, it may be inferred, that Collins had never let Locke fully into the secret of those pernicious opinions which he was afterwards at so much pains to disseminate.

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[1] In the above note, I have said nothing of Leibnitz's project of a philosophical language, founded on an alphabet of Human Thoughts, as he has nowhere given us any hint of the principles on which he intended to proceed in its formation, although he has frequently alluded to the practicability of such an invention in terms of extraordinary confidence. (For some remarks on these passages in his works, see *Philosophy of the Human Mind*, Vol. II. pp. 143, *et seq.)* In some of Leibnitz's expressions on this subject, there is a striking resemblance to those of Descartes in one of his letters.—(See the preliminary discourse prefixed to the Abbé Emery's *Pensées de Descartes*, p. xiv. *et seq.)*

In the ingenious essay of Michaelis *On the Influence of Opinions on Language, and of Language on Opinions* (which obtained the prize from the Royal Society of Berlin in 1759, there are some very acute and judicious reflections on the impossibility of carrying into effect, with any advantage, such a project as these philosophers had in view. The author's argument on this point seems to me decisive, in the present state of human knowledge; but who can pretend to fix a limit to the possible attainments of our posterity!

Note L L, p. 144.

In addition to the account of Spinoza given in Bayle, some interesting particulars of his history may be learnt from a small volume, entitled, *La Vie de B. de Spinoza, tirée des écrits de ce Fameux Philosophe, et du temoignage de plusieurs personnes dignes de foi, qui l'ont connu particuliérement: par* Jean Colerus, *Ministre de l'Eglise Lutherienne de la Haye.* 1706.[1] The book is evidently written by a man altogether unfit to appreciate the merits or demerits of Spinoza as an author; but it is not without some value to those who delight in the study of human character, as it supplies some chasms in the narrative of Bayle, and has every appearance of the most perfect impartiality and candour.

According to this account, Spinoza was a person of the most quiet and inoffensive manners; of singular temperance and moderation in his passions; contented and happy with an income which barely supplied him with the necessaries of life; and of too independent a spirit to accept of any addition to it, either from the favour of princes, or the liberality of his friends. In conformity to the law, and to the customs of his ancestors (which he adhered to, when he thought them not unreasonable, even when under the sentence of excommunication), he resolved to learn some mechanical trade; and fortunately selected that of grinding optical glasses, in which he acquired so much dexterity, that it furnished him with what he conceived to be a sufficient maintenance. He acquired also enough of the art of designing, to produce good portraits in chalk and china-ink, of some distinguished persons.

For the last five years of his life he lodged in the house of a respectable and religious family, who were tenderly attached to him, and from whom his biographer collected various interesting anecdotes. All of them are very creditable to his private character, and more particularly show how courteous and amiable he must have been in his intercourse with his inferiors. In a bill presented for payment after his death, he is styled by Abraham Keveling, his barber-surgeon, *Benedict Spinoza, of blessed memory;* and the same compliment is paid to him by the tradesman who furnished gloves to the mourners at his funeral.

These particulars are the more deserving of notice, as they rest on the authority of a very zealous member of the Lutheran communion, and coincide exactly with the account given of Spinoza by the learned and candid Mosheim. "This man (says he) observed, in his conduct, the rules of wisdom and probity much better than many who profess themselves Christians; nor did he ever endeavour to pervert the sentiments or to corrupt the morals of those with whom he lived; or to inspire, in his discourse, a contempt of religion or virtue."………(*Eccles. History*, translated by Dr Maclaine, Vol. IV. p. 252.)

Among the various circumstances connected with Spinoza's domestic habits, Colerus mentions one very trifling singularity, which appears to me to throw a strong light on his general character, and to furnish some apology for his eccentricities as an author. The extreme feebleness of his constitution (for he was consumptive from the age of 20) having unfitted him for the enjoyment of convivial pleasures, he spent the greater part of the day in his chamber alone; but when fatigued with study, he would sometimes join the family party below, and take a part in their conversation, however insignificant its subject might be. One of the amusements with which he was accustomed to unbend his mind, was that of entangling flies in a spider's web, or of setting spiders a-fighting with each other; on which occasions (it is added) he would observe their combats with so much interest, that it was not unusual for him to be seized with immoderate fits of laughter. Does not this slight *trait* indicate very decidedly a tendency to insanity; a supposition by no means incompatible (as will be readily admitted by all who have paid any attention to the phenomena of madness) with that logical *acumen* which is so conspicuous in some of his writings?

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[1] The Life of Spinoza by Colerus, with some other curious pieces on the same subject, is reprinted in the complete edition of Spinoza's Works, published at Jena, in 1802.

His irreligious principles he is supposed to have adopted, in the first instance, from his Latin preceptor Vander Ende, a physician and classical scholar of some eminence; but it is much more probable, that his chief school of atheism was the synagogue of Amsterdam; where, without any breach of charity, a large proportion of the more opulent class of the assembly may be reasonably presumed to belong to the ancient sect of *Sadducees*. (This is, I presume, the idea of Heineccius in the following passage: " Quamvis Spinoza Cartesii principia methodo mathematica demonstrata dederit; Pantheismum tamen ille non ex Cartesio didicit, sed *domi habuit, quos sequeretur*." In proof of this, he refers to a book entitled *Spinozismus in Judaismo*, by Waechterus.) The blasphemous curses pronounced upon him in the sentence of excommunication were not well calculated to recal him to the faith of his ancestors; and when combined with his early and hereditary prejudices against Christianity, may go far to account for the indiscriminate war which he afterwards waged against priests of all denominations.

The ruling passion of Spinoza seems to have been the love of fame. " It is owned (says Bayle) that he had an extreme desire to immortalise his name, and would have sacrificed his life to that glory, though he should have been torn to pieces by the mob."—(Art. *Spinoza*.)

NOTE MM, p. 148.

In proof of the impossibility of Liberty, Collins argues thus:

" A second reason to prove man a necessary agent is, because all his actions have a beginning. For whatever has a beginning must have a cause; and every cause is a necessary cause.

" If anything can have a beginning, which has no cause, then nothing can produce something. And if nothing can produce something, then the world might have had a beginning without a cause; which is an absurdity not only charged on atheists, but is a real absurdity in itself.* * * * *Liberty, therefore, or a power to act or not to act, to do this or another thing under the same causes, is an *impossibility and atheistical*.[1]

" And as Liberty stands, and can only be grounded on the absurd principles of Epicurean atheism; so the Epicurean atheists, who were the most popular and most numerous sect of the atheists of antiquity, were the great assertors of liberty; as, on the other side, the Stoics, who were the most popular and numerous sect among the religionaries of antiquity, were the great assertors of *fate* and *necessity*."—(COLLINS, p. 54.)

As to the above *reasoning* of Collins, it cannot be expected that I should, in the compass of a Note, " boult this matter to the bran." It is sufficient here to remark, that it derives all its plausibility from the unqualified terms in which the maxim (μηδεν ἀναιτιον) has frequently been stated. " In the idea of every *change* (says Dr Price, a zealous advocate for the freedom of the will) is included that of its being an *effect*." (*Review*, *&c*. p. 30, 3d edition.) If this maxim be literally admitted without any explanation or restriction, it seems difficult to resist the conclusions of the Necessitarians. The proper statement of Price's maxim evidently is, that

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[1] To the same purpose Edwards attempts to show, that " the scheme of free-will (by affording an exception to that dictate of common sense which refers every event to a cause) would destroy the proof *a posteriori* for the being of God."

"in every *change* we perceive in *inanimate* matter, the idea of its being an *effect* is necessarily involved;" and that he himself understood it under this limitation appears clearly from the application he makes of it to the point in dispute. As to intelligent and active beings, to affirm that they possess the power of self-determination, seems to me to be little more than an identical proposition. Upon an accurate analysis of the meaning of words, it will be found that the idea of an *efficient* cause implies the idea of *Mind;* and, consequently, that it is absurd to ascribe the volitions of *mind* to the efficiency of causes foreign to itself. To do so must unavoidably involve us in the inconsistencies of Spinozism; by forcing us to conclude that everything is passive, and nothing active in the universe; and, consequently, that the idea of a *First* Cause involves an impossibility.—But upon these hints I must not enlarge at present; and shall, therefore, confine myself to what falls more immediately within the scope of this Discourse, Collins's Historical Statement with respect to the tenets of the Epicureans and the Stoics.

In confirmation of his assertion concerning the former, he refers to the following well known lines of Lucretius:

> Denique si semper motus connectitur omnis,
> &c. &c. (*Lucret.* Lib. 2. v. 251.)

On the obscurity of this passage, and the inconsistencies involved in it, much might be said; but it is of more importance, on the present occasion, to remark its complete repugnance to the whole strain and spirit of the Epicurean Philosophy. This repugnance did not escape the notice of Cicero, who justly considers Epicurus as having contributed more to establish, by this puerile subterfuge, the authority of Fatalism, than if he had left the argument altogether untouched. "Nec vero quisquam magis confirmare mihi videtur non modo fatum, verum etiam necessitatem et vim omnium rerum, sustulisseque motus animi voluntarios, quam hic qui aliter obsistere fato fatetur se non potuisse nisi ad has commenticias declinationes confugisset."—(*Liber de Fato,* cap. 20.)

On the noted expression of Lucretius (*fatis avolsa voluntas*) some acute remarks are made in a note on the French translation by M. de la Grange. They are not improbably from the pen of the Baron d'Holbach, who is said to have contributed many notes to this translation. Whoever the author was, he was evidently strongly struck with the inconsistency of this particular tenet with the general principles of the Epicurean system.

"On est surpris qu' Epicure fonde la liberté humaine sur la déclinaison des atomes. On demande si cette déclinaison est nécessaire, ou si elle est simplement accidentelle. Nécessaire, comment la liberté peut elle en être le resultat? Accidentelle, par quoi est elle déterminée? Mais on devrait bien plutot être surpris, qu'il lui soit venu en idée de rendre l'homme libre dans un système qui suppose un enchainement nécessaire de causes et d'effets. C'etoit une recherche curieuse, que la raison qui a pu faire d'Epicure l'Apôtre de la Liberté." For the theory which follows on this point, I must refer to the work in question.—(See *Traduction Nouvelle de Lucrece, avec des Notes,* par M. DE LA GRANGE, Vol. I. pp. 218, 219, 220, à Paris, 1768.)

But whatever may have been the doctrines of some of the *ancient* Atheists about man's free-agency, it will not be denied, that in the *History of* MODERN *Philosophy,* the schemes of Atheism and of Necessity have been hitherto always connected together. Not that I would by any means be understood to say, that every Necessitarian must *ipso facto* be an Atheist, or even that any presumption is afforded by a man's attachment to the former sect, of his having the slightest bias in favour of the latter; but only that every modern Atheist I have heard of has been a Necessitarian. I cannot help adding, that the most consistent Necessitarians who have yet appeared, have been those who followed out their principles till they ended in *Spinozism,* a doctrine which differs from atheism more in words than in reality.

In what Collins says of the Stoics in the above quotation, he plainly proceeds on the supposition that all Fatalists are of course Necessitarians;[1] and I agree with him in thinking, that this would be the case, if they reasoned logically. It is certain, however, that a great proportion of those who have belonged to the first sect have disclaimed all connection with the second. The Stoics themselves furnish one very remarkable instance. I do not know any author by whom the liberty of the will is stated in stronger and more explicit terms, than it is by Epictetus in the very first sentence of the Enchiridion. Indeed the Stoics seem, with their usual passion for exaggeration, to have carried their ideas about the freedom of the will to an unphilosophical extreme.

If the belief of man's free-agency has thus maintained its ground among professed Fatalists, it need not appear surprising, that it should have withstood the strong arguments against it, which the doctrine of the eternal decrees of God, and even that of the Divine prescience, appear at first sight to furnish. A remarkable instance of this occurs in St Augustine (distinguished in ecclesiastical history by the title of *the Doctor of Grace)*, who has asserted the liberty of the will in terms as explicit as those in which he has announced the theological dogmas with which it is most difficult to reconcile it. Nay, he has gone so far as to acknowledge the essential importance of this belief, as a motive to virtuous conduct. "Quocirca nullo modo cogimur, aut retenta præscientia Dei, tollere voluntatis arbitrium, aut retento voluntatis arbitrio, Deum, quod nefas est, negare præscium futurorum, sed utrumque amplectimur, utrumque fideliter et veraciter confitemur: illud, ut bene credamus; *hoc ut bene vivamus*."

Descartes has expressed himself on this point nearly to the same purpose with St Augustine. In one passage he asserts, in the most unqualified terms, that God is the cause of all the actions which depend on the Free-will of Man; and yet, that the Will is really free, he considers as a fact perfectly established by the evidence of consciousness. "Sed quemadmodum existentiæ divinæ cognitio non debet liberi nostri arbitrii certitudinem tollere, quia illud in nobismet ipsis experimur et sentimus; ita neque liberi nostri arbitrii cognitio existentiam Dei apud nos dubiam facere debet. Independentia enim illa quam experimur, atque in nobis persentiscimus, et quæ actionibus nostris laude vel vituperio dignis efficiendis sufficit, non pugnat cum dependentia alterius generis, secundum quam omnia Deo subjiciuntur."—(Cartesii *Epistolæ*, Epist. VIII. IX. Pars i.) These letters form part of his correspondence with the Princess Elizabeth, daughter of Frederick, King of Bohemia, and Elector Palatine.

We are told by Dr Priestley, in the very interesting *Memoirs of his own Life*, that he was educated in the strict principles of Calvinism; and yet it would appear, that while he remained a Calvinist, he entertained no doubt of his being a free-agent. "The doctrine of Necessity," he also tells us, "he *first* learned from Collins;[2] and was established in the belief of it by Hartley's *Observations on Man*."—*(Ibid.* p. 19.) He farther mentions in another work, that "he was not a ready convert to the doctrine of Necessity, and that, like Dr Hartley himself, he gave up his liberty with great reluctance."—(*Preface to the Doctrine of Philosophical Necessity Illustrated*, 2d edit. Birmingham, 1782, p. xxvii.)

These instances afford a proof, I do not say of the compatibility of man's free-agency with those schemes with which it seems most at variance, but of this compatibility in the opinion of some of the profoundest thinkers who have turned their attention to the argument. No conclusion, therefore, can be drawn against a man's belief in his own free-agency, from his embracing other metaphysical or theological tenets, with which it may appear to ourselves impossible to reconcile it.

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[1] Collins states this more strongly in what he says of the Pharisees. "The Pharisees, who were a religious sect, ascribed all things to fate or to God's appointment, and it was the first article of their creed, that Fate and God do all, and, consequently, they could not assert a *true* liberty when they asserted a liberty together with this fatality and *necessity* of all things."—(Collins, p. 54.)

[2] We are elsewhere informed by Priestley, that "it was in consequence of reading and studying the *Inquiry* of Collins, he was first convinced of the truth of the doctrine of Necessity, and was enabled to see the fallacy of most of the arguments in favour of Philosophical Liberty: though (he adds) I was much more confirmed in this principle by my acquaintance with Hartley's *Theory of the Human Mind*: a work to which I owe much more than I am able to express."—*(Preface*, &c. &c. p. xxvii.)

As for the notion of liberty, for which Collins professes himself an advocate, it is precisely that of his predecessor Hobbes, who defines a free-agent to be, "he that can do if he will, and forbear if he will."—(HOBBES's *Works*, p. 484, fol. ed.) The same definition has been adopted by Leibnitz, by Gravesande, by Edwards, by Bonnet, and by all our later necessitarians. It cannot be better expressed than in the words of Gravesande: "*Facultas faciendi quod libuerit, quæcunque fuerit voluntatis determinatio.*"—*(Introd. ad Philosoph.* § 115.)

Dr Priestley ascribes this peculiar notion of free-will to Hobbes as its author;[1] but it is, in fact, of much older date even among modern metaphysicians; coinciding exactly with the doctrine of those scholastic divines who contended for the *Liberty of Spontaneity*, in opposition to the *Liberty of Indifference*. It is, however, to Hobbes that the partizans of this opinion are indebted for the happiest and most popular illustration of it that has yet been given. "I conceive," says he, "liberty to be rightly defined, The absence of all the impediments to action that are not contained in the nature and intrinsical quality of the agent. As, for example, the water is said to descend *freely*, or to have liberty to descend by the channel of the river, because there is no impediment that way: but *not* across, because the banks are impediments. And, though water cannot ascend, yet men never say, it wants the *liberty* to ascend, but the *faculty* or power, because the impediment is in the nature of the water, and intrinsical. So also we say, he that is tied wants the *liberty* to go, because the impediment is not in him, but in his hands; whereas we say not so of him who is sick or lame, because the impediment is in himself."—*(Treatise of Liberty and Necessity.)*

According to Bonnet, "moral liberty is the power of the mind to obey without constraint the impulse of the motives which act upon it." This definition, which is obviously the same in substance with that of Hobbes, is thus very justly, as well as acutely, animadverted on by Cuvier. "N'admettant aucune action sans motif, comme dit-il, il n'y a aucun effet sans cause, Bonnet definit la *liberté morale* le pouvoir de l'âme de suivre sans contrainte les motifs dont elle éprouve l'impulsion; et résout ainsi les objections que l'on tire de la prévision de Dieu; mais peut-être aussi detournent-t-il l'idée qu'on se fait d'ordinaire de la liberté. Malgré ces opinions que touchent au Matérialisme et au Fatalisme, Bonnet fut très religieux."—*(Biographie Universelle*, à Paris, 1812. Art. *Bonnet.)*

From this passage it appears, that the very ingenious writer was as completely aware as Clarke or Reid, of the unsoundness of the definition of *moral liberty* given by Hobbes and his followers; and that the ultimate tendency of the doctrine which limits the free-agency of man to (what has been called) the *liberty of spontaneity*, was the same, though in a more disguised form, with that of fatalism.

For a complete exposure of the futility of this definition of *liberty*, as the word is employed in the controversy about man's free-agency, I have only to refer to Clarke's remarks on Collins, and to Dr Reid's *Essays on the Active Powers of Man.* In this last work, the various meanings of this very ambiguous word are explained with great accuracy and clearness.

The only two opinions which, in the actual state of metaphysical science, ought to be stated in contrast, are that of Liberty (or free-will) on the one side, and that of Necessity on the other. As to the *Liberty of Spontaneity* (which expresses a fact altogether foreign to the point in question), I can conceive no motive for inventing such a phrase, but a desire in some writers to veil the scheme of necessity from their readers, under a language less revolting to the sentiments of mankind; and, in others, an anxiety to banish it as far as possible from their own thoughts, by substituting instead of the terms in which it is commonly expressed, a circumlocution which seems, on a superficial view, to concede something to the advocates for liberty.

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[1] "The doctrine of philosophical necessity," says Priestley, "is in reality a modern thing, not older, I believe, than Mr Hobbes. Of the Calvinists, I believe Mr Jonathan Edwards to be the first."—(*Illustrations of Philosophical Necessity*, p. 195.)

Supposing this statement to be correct, does not the very modern date of Hobbes's alleged *discovery* furnish a very strong presumption against it?

If this phrase (the *Liberty of Spontaneity*) should fall into disuse, the other phrase (the *Liberty of Indifference*),[1] which is commonly stated in opposition to it, would become completely useless; nor would there be occasion for qualifying with any epithet, the older, simpler, and much more intelligible word, *Free-will.*

The distinction between *physical* and *moral* necessity I conceive to be not less frivolous than those to which the foregoing animadversions relate. On this point I agree with Diderot, that the word *necessity* (as it ought to be understood in this dispute) admits but of *one* interpretation.

NOTE N N, p. 148.

To the arguments of Collins, against man's free-agency, some of his successors have added, the inconsistency of this doctrine with the known *effects of education* (under which phrase they comprehend the moral effects of all the external circumstances in which men are involuntarily placed) in forming the characters of individuals.

The plausibility of this argument (on which much stress has been laid by Priestley and others) arises entirely from the mixture of truth which it involves; or, to express myself more correctly, from the evidence and importance of the *fact* on which it proceeds, when that fact is stated with due limitations.

That the influence of *education*, in this comprehensive sense of the word, was greatly underrated by our ancestors, is now universally acknowledged; and it is to Locke's writings, more than to any other single cause, that the change in public opinion on this head is to be ascribed. On various occasions, he has expressed himself very strongly with respect to the *extent* of this influence; and has more than once intimated his belief, that the great majority of men continue through life what early education had made them. In making use, however, of this strong language, his object (as is evident from the opinions which he has avowed in other parts of his works) was only to arrest the attention of his readers to the practical lessons he was anxious to inculcate; and not to state a metaphysical fact which was to be literally and rigorously interpreted in the controversy about liberty and necessity. The only sound and useful *moral* to be drawn from the *spirit* of his observations, is the duty of gratitude to Heaven for all the blessings, in respect of education and of external situation, which have fallen to our own lot; the impossibility of ascertaining the involuntary misfortunes by which the seeming demerits of others may have been in part occasioned, and in the same proportion diminished; and the consequent obligation upon ourselves, to think as charitably as possible of their conduct, under the most unfavourable appearances. The truth of all this I conceive to be implied in these words of Scripture, " To whom much is given, of him much will be required;" and, if possible, still more explicitly and impressively, in the parable of the Talents.

Is not the use which has been made by Necessitarians of Locke's *Treatise on Education*, and other books of a similar tendency, only one instance more of that disposition, so common among metaphysical Sciolists, to appropriate to themselves the conclusions of their wiser and more sober predecessors, under the startling and imposing disguise of universal maxims, admitting neither of exception nor restriction? It is thus that Locke's judicious and refined remarks on the *Association of Ideas* have been exaggerated to such an extreme in the coarse *caricatures* of Hartley and of Priestley, as to bring, among cautious inquirers, some degree of discredit on one of the most important doctrines of modern philosophy. Or, to take another case still more in point; it is thus that Locke's reflections on the effects of education in modifying the intellectual faculties, and (where skilfully conducted) in supplying their original defects, have been distorted into the puerile paradox of Helvetius, that the mental capacities of the whole human race are the same at the moment of birth. It is sufficient for me here to throw out these hints, which will be found to apply equally to a large proportion of other theories started by modern metaphysicians.

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[1] Both phrases are favourite expressions with Lord Kames in his discussions on this subject. See in particular the Appendix to his *Essay on Liberty and Necessity*, in the last edition of his *Essays on Morality and Natural Religion.*

Before I finish this note, I cannot refrain from remarking, with respect to the argument for Necessity drawn from the Divine prescience, that, if it be conclusive, it only affords an additional confirmation of what Clarke has said concerning the identity of the creed of the Necessitarians with that of the Spinozists. For, if God certainly foresees all the future volitions of his creatures, he must, for the same reason, foresee all *his own* future volitions; and if this knowledge infers *a necessity* of volition in the one case, how is it possible to avoid the same inference in the other?

Note OO, p. 149.

A similar application of St Paul's comparison of the *potter* is to be found both in Hobbes and in Collins. Also, in a note annexed by Cowley to his ode entitled *Destiny;* an ode written (as we are informed by the author) " upon an extravagant supposition of two angels playing a game at chess; which, if they did, the spectators would have reason as much to believe that the pieces moved themselves, as we have for thinking the same of mankind, when we see them exercise so many and so different actions. It was of old said by Plautus, *Dii nos quasi pilas homines habent,* " We are but tennis-balls for the gods to play withal," which they strike away at last, and still call for new ones; and St Paul says, " *We are but the clay in the hand of the potter.*"

For the comparison of the *potter*, alluded to by these different writers, see the epistle to the Romans, chap. ix. verses 18, 19, 20, 21. Upon these verses the only comment which I have to offer is a remark of the apostle Peter, that " In the epistles of our beloved brother Paul are some things hard to be understood, which they that are unlearned and unstable wrest unto their own destruction."

The same similitude of the *potter* makes a conspicuous figure in the writings of Hobbes, who has availed himself of this, as of many other insulated passages of Holy Writ, in support of principles which are now universally allowed to strike at the very root of religion and morality. The veneration of Cowley for Hobbes is well known, and is recorded by himself in the ode which immediately precedes that on Destiny. It cannot, however, be candidly supposed, that Cowley understood the whole drift of Hobbes' doctrines. The contrary, indeed, in the present instance, is obvious from the ode before us; for while Cowley supposed the angels to move, like chess-men, the inhabitants of this globe, Hobbes (along with Spinoza) plainly conceived that the angels themselves, and even that Being to which he impiously gave the name of *God*, were all of them moved, like knights and pawns, by the invisible hand of fate or necessity.

Were it not for the serious and pensive cast of Cowley's mind, and his solemn appeal to the authority of the apostle, in support of the doctrine of *destiny*, one would be tempted to consider the first stanzas of this ode in the light of a *jeu d'esprit*, introductory to the very characteristical and interesting picture of himself, with which the poem concludes.

Note PP, p. 150.

" Tout ce qui est doit être, par cela même que cela est. Voilà la seule bonne philosophie. Aussi longtemps que nous ne connaîtrons pas cet univers, comme on dit dans l'école, *a priori*, tout est nécessité. La liberté est un mot vide de sens, comme vous allez voir dans la lettre de M. Diderot."—(*Lettre de Grimm au Duc de Saxe-Gotha.*)

" C'est ici, mon cher, que je vais quitter le ton de prédicateur pour prendre, si je peux, celui de philosophe. Regardez-y de près, et vous verrez que le mot liberté est un mot vide de sens; qu'il n'y a point, et qu'il ne peut y avoir d'êtres libres; que nous ne sommes que ce qui convient à l'ordre général, à l'organisation, à l'éducation, et à la chaîne des événemens. Voilà ce qui dispose de nous invinciblement.

On ne conçoit non plus qu'un être agisse sans motif, qu'un des bras d'une balance agisse sans l'action d'un poids, et le motif nous est toujours extérieur, étranger, attaché ou par une nature ou par une cause quelconque, qui n'est pas nous. Ce qui nous trompe, c'est la prodigieuse variété de nos actions, jointe à l'habitude que nous avons prise tout en naissant, de confondre le volontaire avec le libre. Nous avons tant loué, tant repris, nous l'avons été tant de fois, que c'est un préjugé bien vieux que celui de croire que nous et les autres voulons, agissons librement. Mais s'il n'y a point de liberté, il n'y a point d'action qui mérite la louange ou le blâme; il n'y a ni vice, ni vertu, rien dont il faille récompenser ou châtier. Qu'est ce qui distingue donc les hommes? La bienfaisance ou la malfaisance. Le malfaisant est un homme qu'il faut détruire et non punir; la bienfaisance est une bonne fortune, et non une vertu. Mais quoique l'homme bien ou malfaisant ne soit pas libre, l'homme n'en est pas moins un être qu'on modifie; c'est par cette raison qu'il faut détruire le malfaisant sur une place publique. De là les bons effets de l'exemple, des discours, de l'éducation, du plaisir, de la douleur, des grandeurs, de la misère, &c.; de là un sorte de philosophie pleine de commisération, qui attache fortement aux bons, qui n'irrite non plus contre le méchant, que contre un ouragan qui nous remplit les yeux de poussière. Il n'y a qu'une sorte de causes à proprement parler; ce sont les causes physiques. Il n'y a qu'une sorte de nécessité, c'est la même pour tous les êtres. Voilà ce qui me réconcilie avec le genre humain; c'est pour cette raison que je vous exhortais à la philanthropie. Adoptez ces principes si vous les trouvez bons, ou montrez-moi qu'ils sont mauvais. Si vous les adoptez, ils vous réconcilieront aussi avec les autres et avec vous-même; vous ne vous saurez ni bon ni mauvais gré d'être ce qui vous êtes. Ne rien réprocher aux autres, ne se répentir de rien; voilà les premiers pas vers la sagesse. Ce qui est hors de là est préjugé, fausse philosophie."—(*Correspondance Littéraire, Philosophique, et Critique, addressée au Duc de Saxe-Gotha*, par le BARON DE GRIMM et par DIDEROT. Première Partie, Tom. I. pp. 300, 304, 305, 306, Londres, 1814.)

NOTE Q Q, p. 156.

See in Bayle the three articles *Luther*, *Knox*, and *Buchanan*. The following passage concerning Knox may serve as a specimen of the others. It is quoted by Bayle from the *Cosmographie Universelle* of Thevet, a writer who has long sunk into the contempt he merited, but whose zeal for legitimacy and the Catholic faith raised him to the dignity of almoner to Catherine de Medicis, and of historiographer to the King of France. I borrow the translation from the English *Historical Dictionary*.

"During that time the Scots never left England in peace; it was when Henry VIII. played his pranks with the chalices, relics, and other ornaments of the English churches; which tragedies and plays have been acted in our time in the kingdom of Scotland, by the exhortations of Noptz,[1] the first Scots minister of the bloody Gospel. This firebrand of sedition could not be content with barely following the steps of Luther, or of his master, Calvin, who had not long before delivered him from the gallies of the Prior of Capua, where he had been three years for his crimes, unlawful amours, and abominable fornications; for he used to lead a dissolute life, in shameful and odious places, and had been also found guilty of the parricide and murder committed on the body of the Archbishop of St Andrew's, by the contrivances of the Earl of Rophol, of James Lescle, John Lescle, their uncle, and William du Coy. This simonist, who had been a priest of our church, being fattened by the benefices he had enjoyed, sold them for ready money; and finding that he could not make his cause good, he gave himself up to the most terrible blasphemies. He persuaded also several devout wives and religious virgins to abandon themselves to wicked adulterers. Nor was this all. During two whole years, he never ceased to rouse the people, encouraging them to

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[1] Thus Thevet (says Bayle) writes the name of Knox.

take up arms against the Queen, and to drive her out of the kingdom, which he said was elective, as it had been formerly in the time of heathenism. . . . . The Lutherans have churches and oratories. Their ministers sing psalms, and say mass; and though it be different from ours, yet they add to it the Creed, and other prayers, as we do. And when their ministers officiate, they wear the cope, the chasuble, and the surplice, as ours do, being concerned for their salvation, and careful of what relates to the public worship. Whereas the Scots have lived these twelve years past without laws, without religion, without ceremonies, constantly refusing to own a King or a Queen, as so many brutes, suffering themselves to be imposed upon by the stories told them by this arch-hypocrite Noptz, a traitor to God and to his country, rather than to follow the pure Gospel, the councils, and the doctrine of so many holy doctors, both Greek and Latin, of the Catholic church."

If any of my readers be yet unacquainted with the real character and history of this distinguished person, it may amuse them to compare the above passage with the very able, authentic, and animated account of his life, lately published by the reverend and learned Dr M'Crie.

Note R R, p. 161.

Dr Blair, whose estimate of the distinguishing beauties and imperfections of Addison's style reflects honour on the justness and discernment of his taste, has allowed himself to be carried along much too easily, by the vulgar sneers at Addison's want of philosophical depth. In one of his lectures on rhetoric he has even gone so far as to accuse Addison of misapprehending, or, at least, of *mis-stating*, Locke's doctrine concerning *secondary qualities*. But a comparison of Dr Blair's own statement with that which he censures, will not turn out to the advantage of the learned critic; and I willingly lay hold of this example, as the point at issue turns on one of the most refined questions of metaphysics. The words of Addison are these:—

"Things would make but a poor appearance to the eye, if we saw them only in their proper figures and motions. And what reason can we assign for their exciting in us many of those ideas which are different from anything that exists in the objects themselves (for such are light and colours), were it not to add supernumerary ornaments to the universe, and make it more agreeable to the imagination?"

After quoting this sentence, Dr Blair proceeds thus:—

"Our author is now entering on a theory, which he is about to illustrate, if not with much philosophical accuracy, yet with great beauty of fancy and glow of expression. A strong instance of his want of accuracy appears in the manner in which he opens the subject. For what meaning is there in things *exciting in us many of those ideas which are different from anything that exists in the objects?* No one, sure, ever imagined that our ideas exist in the objects. Ideas, it is agreed on all hands, can exist nowhere but in the mind. What Mr Locke's philosophy teaches, and what our author should have said, is, *exciting in us many ideas of qualities which are different from anything that exists in the objects.*"

Let us now attend to Locke's theory, as stated by himself:—

"From whence I think it is easy to draw this observation, That the *ideas* of primary qualities of bodies are *resemblances* of them, *and their patterns do really exist in the bodies themselves*, but the *ideas* produced in us by these secondary qualities have *no resemblance* of them at all. There is nothing *like* our ideas existing in the bodies themselves. They are in the bodies we denominate from them, only a power to produce these sensations in us. And what is sweet, blue, or warm in *idea*, is but the certain bulk, figure, and motion of the insensible parts in the bodies themselves, which we call so."

The inaccuracy of Locke in conceiving that our *ideas* of primary qualities are *resemblances* of these qualities, and that the *patterns* of such ideas exist in the bodies themselves, has been fully exposed by Dr Reid. But the *repetition* of Locke's inaccuracy (supposing Addison to have been really guilty of it) should not be charged upon him as a *deviation* from his master's doctrine. To all, however, who understand the subject, it must appear evident, that Addison has, in this instance, *improved* greatly on Locke, by keeping out of view what is most exceptionable in his language, while he has retained all that is solid in his doctrine. For my own part, I do not see how Addison's expressions could be altered to the better, except, perhaps, by substituting the words *unlike to*, instead of *different from.* But in this last phrase, Addison has been implicitly followed by Dr Blair, and certainly would not have been disavowed as an interpreter by Locke himself. Let me add, that Dr Blair's proposed emendation ("exciting in us many ideas *of qualities*, which are different from any thing that exists in the objects"), if not wholly unintelligible, deviates much farther from Locke's meaning than the correspondent clause in its original state. The additional words *of qualities* throw an obscurity over the whole proposition, which was before sufficiently precise and perspicuous.[1]

My principal reason for offering these remarks in vindication of Addison's account of secondary qualities was, to prepare the way for the sequel of the passage animadverted on by Dr Blair.

"We are everywhere entertained with pleasing shows and apparitions. We discover imaginary glories in the heavens and in the earth, and see some of this visionary beauty poured out upon the whole creation. But what a rough unsightly sketch of nature should we be entertained with, did all her colouring disappear, and the several distinctions of light and shade vanish?[2] In short, our souls are delightfully lost and bewildered in a pleasing delusion, and we walk about like the enchanted hero of a romance, who sees beautiful castles, woods, and meadows, and, at the same time, hears the warbling of birds and the purling of streams; but, upon the finishing of some secret spell, the fantastic scene breaks up, and the disconsolate knight finds himself on a barren heath, or in a solitary desert."

In this passage one is at a loss whether most to admire the author's depth and refinement of thought, or the singular felicity of fancy displayed in its illustration. The image of the *enchanted hero* is so unexpected, and, at the same time, so exquisitely appropriate, that it seems itself to have been conjured up by an enchanter's wand. Though introduced with the unpretending simplicity of a poetical simile, it has the effect of shedding the light of day on one of the darkest corners of metaphysics. Nor is the language in which it is conveyed unworthy of the attention of the critic; abounding throughout with those natural and happy graces, which appear artless and easy to all but to those who have attempted to copy them.

The praise which I have bestowed on Addison as a commentator on this part of Locke's Essay will not appear extravagant to those who may take the trouble to compare the conciseness and elegance of the foregoing extracts with the prolixity and homeliness of the author's text. (See LOCKE's *Essay*, Book II. chap. viii. §§ 17, 18.) It is sufficient to mention here, that his chief illustration is taken from "the effects of manna on the stomach and guts."

NOTE S S, p. 168.

For the following note I am indebted to my learned friend Sir William Hamilton, Professor of Universal History in the University of Edinburgh.

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[1] Another passage, afterwards quoted by Dr Blair, might have satisfied him of the clearness and accuracy of Addison's ideas on the subject.

"I have here supposed that my reader is acquainted with that great modern discovery, which is, at present, universally acknowledged by all the inquirers into Natural Philosophy; namely, that light and colours, *as apprehended by the imagination*, are only ideas in the mind, and not qualities that have any existence in matter. As this is a truth which has been proved incontestibly by many modern philosophers, if the English reader would see the notion explained at large, he may find it in the eighth book of Mr Locke's *Essay on Human Understanding.*"

I have already taken notice (*Elements of the Philosophy of the Human Mind*, Vol. I. Note P.) of the extraordinary precision of the above statement, arising from the clause printed in Italics. By a strange slip of memory I ascribed the merit of this very judicious qualification, not to Addison, but to Dr Akenside, who transcribed it from the Spectator.

The last quotation affords me also an opportunity of remarking the correctness of Addison's information about the history of this doctrine, which most English writers have conceived to be an original speculation of Locke's. From some of Addison's expressions, it is more than probable, that he had derived his first knowledge of it from Malebranche.

[2] On the supposition made in this sentence, the face of Nature, instead of presenting a "rough unsightly sketch," would, it is evident, become wholly invisible. But I need scarcely say, this does not render Mr Addison's allusion less pertinent.

"The *Clavis Universalis* of Arthur Collier, though little known in England, has been translated into German. It is published in a work entitled "*Samlung*," &c. &c. literally, "A Collection of the most distinguished Authors who deny the existence of their own bodies, and of the whole material world,—containing the dialogues of Berkeley, between Hylas and Philonous, and Collier's *Universal Key* translated, with Illustrative Observations, and an Appendix, wherein the existence of Body is demonstrated, by John Christopher Eschenbach, Professor of Philosophy in Rostock." (Rostock, 1756, 8vo.) The remarks are numerous, and show much reading. The Appendix contains, 1. An exposition of the opinion of the Idealists, with its grounds and arguments 2. A proof of the external existence of body. The argument on which he chiefly dwells to show the existence of matter is the same with that of Dr Reid, in so far as he says, "a direct proof must not here be expected; in regard to the fundamental principles of human nature, this is seldom possible, or rather is absolutely impossible." He argues at length, that the Idealist has no better proof of the existence of his soul than of the existence of his body; "when an Idealist says, *I am a thinking being; of this I am certain from internal conviction*;—I would ask from whence he derives this certainty, and why he excludes from this conviction the possibility of deception? He has no other answer than this, *I feel it. It is impossible that I can have any representation of self without the consciousness of being a thinking being.* In the same manner, Eschenbach argues that the *feeling* applies to the existence of body, and that the ground of belief is equally strong and conclusive, in respect to the reality of the *objective*, as of the *subjective*, in perception."

Note TT, p. 182.

"*And yet Diderot, in some of his lucid intervals, seems to have thought and felt very differently.*"

The following passage (extracted from his *Pensées Philosophiques*) is pronounced by La Harpe to be not only one of the most eloquent which Diderot has written, but to be one of the best comments which is any where to be found on the Cartesian argument for the existence of God. It has certainly great merit in point of reasoning; but I cannot see with what propriety it can be considered as a comment upon the argument of Descartes; nor am I sure if, in point of eloquence, it be as well suited to the English as to the French taste.

"Convenez qu'il y auroit de la folie à refuser à vos semblables la faculté de penser. Sans doute, mais que s'ensuit-il de là? Il s'ensuit, que si l'univers, que dis-je l'univers, si l'aile d'un papillon m'offre des traces mille fois plus distinctes d'une intelligence que vous n'avez d'indices que votre semblable a la faculté de penser, il est mille fois plus fou de nier qu'il existe un Dieu, que de nier que votre semblable pense. Or, que cela soit ainsi, c'est à vos lumières, c'est à votre conscience que j'en appelle. Avez-vous jamais remarqué dans les raisonnemens, les actions, et la conduite de quelque homme que ce soit, plus d'intelligence, d'ordre, de sagacité, de conséquence, que dans le mécanisme d'un insecte? La divinité n'est elle pas aussi clairement empreinte dans l'œil d'un ciron, que la faculté de penser dans les écrits du grand Newton? Quoi! le monde formé prouverait moins d'intelligence, que le monde expliqué? Quelle assertion! l'intelligence d'un premier être ne m'est pas mieux demontrée par ses ouvrages, que la faculté de penser dans un philosophe par ses écrits? Songez donc que je ne vous objecte que l'aile d'un papillon, quand je pourrais vous écraser du poids de l'univers."

This, however, was certainly not the creed which Diderot professed in his more advanced years. The article, on the contrary, which immediately follows the foregoing quotation, there is every reason to think, expresses his real sentiments on the subject. I transcribe it at length, as it states clearly and explicitly the same argument which is indirectly hinted at in a late publication by a far more illustrious author.

"J'ouvre les cahiers d'un philosophe célèbre, et je lis: 'Athées, je vous accorde que le mouvement est essentiel à la matière; qu'en concluez-vous? que le monde resulte du jet fortuit d'atomes? J'aimerois autant que vous me dissiez que l'Iliade d'Homère ou la Henriade de Voltaire est un resultat de jets fortuits de caractères?' Je me garderai bien de faire ce raisonnement à un athée. Cette comparaison lui donneroit beau jeu. Selon les lois de l'analyse des sorts, me diroit-il, je ne doit être surpris qu'une chose arrive, lorsqu'elle est possible, et que la difficulté de l'événement est compensée par la quantité des jets. Il y a tels nombre de coups dans lesquels je gagerois avec avantage d'amener cent mille six à la fois avec cent mille des. Quelle que fût la somme finie de caractères avec laquelle on me proposeroit d'engendrer fortuitement l'Iliade, il y a telle somme finie de jets qui me rendroit la proposition avantageuse; mon avantage seroit même infini, si la quantité de jets accordée étoit infinie," &c. &c. —(*Pensées Philosophiques*, par DIDEROT, XXI.)

My chief reason for considering this as the genuine exposition of Diderot's own creed is, that he omits no opportunity of suggesting the same train of thinking in his other works. It may be distinctly traced in the following passage of his *Traité du Beau*, the substance of which he has also introduced in the article *Beau* of the *Encyclopédie*.

"Le beau n'est pas toujours l'ouvrage d'une cause intelligente; le mouvement etablit souvent, soit dans un être consideré solitairement, soit entre plusieurs êtres comparés entr'eux, une multitude prodigieuse de rapports surprenans. Les cabinets d'histoire naturelle en offrent un grand nombre d'exemples. Les rapports sont alors des resultats de combinaisons fortuites, du moins par rapport à nous. La nature imite en se jouant, dans cent occasions, les productions d'art; et l'on pourroit demander, je ne dis pas si ce philosophe qui fût jeté par une tempête sur les bords d'une Ile inconnue, avoit raison de se crier, à la vue de quelque figures de geometrie; '*Courage, mes amis, voici des pas d'hommes;*' mais combien il faudroit remarquer de rapports dans un être, pour avoir une certitude complète qu'il est l'ouvrage d'un artiste[1] (en quelle occasion, un seul defaut de symmetrie prouveroit plus que toute somme donnée de rapports); comment sont entr'eux le temps de l'action de la cause fortuite, et les rapports observés dans les effets produits; et si (à l'exception des œuvres du Tout-Puissant)[2] il y a des cas où le nombre des rapports ne puisse jamais être compensé par celui des jets."

With respect to the passages here extracted from Diderot, it is worthy of observation, that if the atheistical argument from chances be conclusive in its application to that order of things which we behold, it is not less conclusive when applied to every other possible combination of atoms which imagination can conceive, and affords a mathematical proof, that the fables of Grecian mythology, the tales of the genii, and the dreams of the Rosicrusians, *may*, or rather *must*, all of them, be somewhere or other realized in the infinite extent of the universe: a proposition which, if true, would destroy every argument for or against any given system of opinions founded on the reasonableness or the unreasonableness of the tenets involved in it; and would, of consequence, lead to the subversion of the whole frame of the human understanding.[3]

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[1] Is not this precisely the sophistical mode of questioning known among Logicians by the name of *Sorites* or *Acervus?* "Vitiosum sane," says Cicero, "et captiosum genus."—(*Acad. Quæst.* Lib. IV. xvi.)

[2] To those who enter fully into the spirit of the foregoing reasoning, it is unnecessary to observe, that this parenthetical clause is nothing better than an ironical *salvo.* If the argument proves any thing, it leads to this general conclusion, that the apparent order of the universe affords no evidence whatever of the existence of a designing cause.

[3] The atheistical argument here quoted from Diderot is, at least, as old as the time of Epicurus.

> Nam certe neque consilio primordia rerum
> Ordine se quæque, atque sagaci mente locarunt
> Nec quos quæque darent motus pepigere profecto;
> Sed quia multimodis, multis, mutata, per omne
> Ex infinito vexantur percita plagis,
> Omne genus motus, et cœtus experiundo,
> Tandem deveniunt in taleis dispondituras,
> Qualibus hæc rebus consistit summa creata.—(LUCRET. Lib. I. l. 1020.)

And still more explicitly in the following lines:

> Nam cum respicias immensi temporis omne
> Præteritum spatium; tum motus materialis
> Multimodi quam sint; facile hoc adcredere possis,
> Semina sæpe in eodem, ut nunc sunt, ordine pôsta.—(*Ibid.* Lib. III. l. 867.)

Notes and Illustrations.

Mr Hume, in his *Natural History of Religion* (Sect. XI.), has drawn an inference from the internal evidence of the Heathen Mythology, in favour of the supposition that it may not be altogether so fabulous as is commonly supposed. "The whole mythological system is so natural, that in the vast variety of planets and worlds contained in this universe, *it seems more than probable*, that somewhere or other it is really carried into execution." The argument of Diderot goes much farther, and leads to an extension of Mr Hume's conclusion to all conceivable systems, whether *natural* or not.

But further, since the human mind, and all the numberless displays of wisdom and of power which it has exhibited, are ultimately to be referred to a fortuitous concourse of atoms, why might not the Supreme Being, such as we are commonly taught to regard him, have been Himself (as well as the Gods of Epicurus)[1] the result of the continued operation of the same blind causes? or rather, *must* not such a Being have necessarily resulted from these causes operating from all eternity, through the immensity of space?—a conclusion, by the way, which, according to Diderot's own principles, would lead us to refer the era of his origin to a period indefinitely more remote than any given point of time which imagination can assign; or, in other words, to a period to which the epithet *eternal* may with perfect propriety be applied. The amount, therefore, of the whole matter is this, that the atheistical reasoning, as stated by Diderot, leaves the subject of natural, and, I may add, of revealed religion, precisely on the same footing as before, without invalidating, in the very smallest degree, the evidence for any one of the doctrines connected with either; nay more, superadding to this evidence, a mathematical demonstration of the *possible* truth of all those articles of belief which it was the object of Diderot to subvert from their foundation.

It might be easily shown, that these principles, if pushed to their legitimate consequences, instead of establishing the just authority of reason in our constitution, would lead to the most unlimited credulity on all subjects whatever; or (what is only another name for the same thing) to that state of mind, which, in the words of Mr Hume, "does not consider any one proposition as more certain, or even as more probable, than another."

Notes and Illustrations.

The following curious and (in my opinion) instructive anecdote has a sufficient connection with the subject of this note, to justify me in subjoining it to the foregoing observations. I transcribe it from the Notes annexed to the Abbé de Lille's poem entitled *La Conversation.* (A Paris, 1812.)

"Dans la société du Baron d'Holbach, Diderot proposa un jour de nommer un *avocat de Dieu*, et on choisit l'Abbé Galiani. Il s'assit et débuta ainsi:

"Un jour à Naples, un homme de la Basilicate prit devant nous, six dés dans un cornet, et paria d'amener rafle de six. Je dis cette chance étoit possible. Il l'amena sur le champ une seconde fois; je dis la même chose. Il remit les dés dans le cornet trois, quatre, cinq fois, et toujours rafle de six. *Sangue di Bacco*, m'ecriai-je, *les dés sont pipés;* et ils l'étoient.

"Philosophes, quand je considère l'ordre toujours renaissant de la nature, ses lois immuables, ses révolutions toujours constantes dans une variété infinie; cette chance unique et conservatrice d'un univers tel que nous le voyons, qui revient sans cesse, malgré cent autres millions de chances de perturbation et de destruction possibles, je m'ecrie: *certes la nature est pipée!*"

The argument here stated strikes me as irresistible; nor ought it at all to weaken its effect, that it was spoken by the mouth of the Abbé Galiani.

Whatever his own professed principles may have been, this theory of the *loaded die* appears evidently, from the repeated allusions to it in his familiar correspondence, to have produced a very deep impression on his mind.—(See *Correspondance inédite de* l'Abbé Galiani, &c. Vol. I. pp. 18, 42, 141, 142, à Paris, 1818.)

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[1] Cic. *de Nat. Deor.* Lib. I. XXIV.

As the old argument of the atomical atheists is plainly that on which the school of Diderot are still disposed to rest the strength of their cause, I shall make no apology for the length of this note. The *sceptical* suggestions on the same subject which occur in Mr Hume's *Essay on the Idea of Necessary Connection*, and which have given occasion to so much discussion in this country, do not seem to me to have ever produced any considerable impression on the French philosophers.

Note U U, p. 182.

Among the contemporaries of Diderot, the author of the *Spirit of Laws* is entitled to particular notice, for the respect with which he always speaks of natural religion. A remarkable instance of this occurs in a letter to Dr Warburton, occasioned by the publication of his *View of Bolingbroke's Philosophy*. The letter, it must be owned, savours somewhat of the political religionist; but how fortunate would it have been for France, if, during its late revolutionary governments, such sentiments as those here expressed by Montesquieu had been more generally prevalent among his countrymen! "Celui qui attaque la religion révélée n'attaque que la religion révélée; mais celui qui attaque la religion naturelle attaque toutes les religions du monde. . . . Il n'est pas impossible d'attaquer une religion révélée, parce qu'elle existe par des faits particuliers, et que les faits par leur nature peuvent être une matière de dispute; mais il n'en est pas de même de la religion naturelle; elle est tirée de la nature de l'homme, dont on ne peut pas disputer encore. J'ajoute à ceci, quel peut être le motif d'attaquer la religion révélée en Angleterre? On l'y a tellement purgé de tout prejugé destructeur qu'elle n'y peut faire de mal et qu'elle y peut faire, au contraire, une infinité de biens. Je sais, qu'un homme en Espagne ou en Portugal que l'on va bruler, ou qui craint d'être brulé, parce qu'il ne croit point de certains articles dépendans ou non de la religion révélée, a un juste sujet de l'attaquer, parce qu'il peut avoir quelque espérance de pourvoir à sa défense naturelle: mais il n'en est pas de même en Angleterre, où tout homme qui attaque la religion révélée l'attaque sans intéret, et où cet homme, quand il réussiroit, quand même il auroit raison dans le fond, ne feroit que détruire une infinité de biens pratiques, pour établir une vérité purement spéculative."—(For the whole letter, see the 4to edit. of Montesquieu's *Works*. Paris, 1788. Tome V. p. 391. Also Warburton's *Works* by Hurd, Vol. VII. p. 553. London, 1758.)

In the foregoing passage, Montesquieu hints more explicitly than could well have been expected from a French magistrate, at a consideration which ought always to be taken into the account, in judging of the works of his countrymen, when they touch on the subject of religion; I mean, the corrupted and intolerant spirit of that system of faith which is immediately before their eyes. The eulogy bestowed on the church of England is particularly deserving of notice, and should serve as a caution to Protestant writers against making common cause with the defenders of the church of Rome.

With respect to Voltaire, who, amidst all his extravagancies and impieties, is well known to have declared open war against the principles maintained in the *Systême de la Nature*, it is remarked by Madame de Staël, that two different epochs may be distinguished in his literary life; the one, while his mind was warm from the philosophical lessons he had imbibed in England; the other, after it became infected with those extravagant principles which, soon after his death, brought a temporary reproach on the name of Philosophy. As the observation is extended by the very ingenious writer to the French nation in general, and draws a line between two classes of authors who are frequently confounded together in this country, I shall transcribe it in her own words.

"Il me semble qu'on pourroit marquer dans le dix-huitième siècle, en France, deux époques parfaitement distinctes, celle dans laquelle l'influence de l'Angleterre s'est fait sentir, et celle où les esprits se sont précipités dans la destruction: Alors les lumières se sont changées en incendie, et la philosophie, magicienne irritée, a consumé le palais où elle avoit étalé ses prodiges.

"En politique, Montesquieu appartient à la première époque, Raynal à la seconde; en religion, les ecrits de Voltaire, qui avoit la tolerance pour but, sont inspirés par l'esprit de la première moitié du siècle, mais sa miserable et vaniteuse irréligion a flétri la seconde."—*(De l'Allemagne*, Tome III. pp. 37, 38.)

Nothing, in truth, can be more striking than the contrast between the spirit of Voltaire's early and of his later productions. From the former may be quoted some of the sublimest sentiments anywhere to be found, both of religion and of morality. In some of the latter, he appears irrecoverably sunk in the abyss of fatalism. Examples of both are so numerous, that one is at a loss in the selection. In making choice of the following, I am guided chiefly by the comparative shortness of the passages.

> "Consulte Zoroastre et Minos, et Solon,
> Et le sage Socrate, et le grand Ciceron:
> Ils ont adoré tous un maître, un juge, un père;—
> Ce système sublime à l'homme est nécessaire.
> C'est le sacré lien de la société,
> Le premier fondement de la sainte équité;
> Le frein du scélérat, l'éspérance du juste.
> Si les cieux, depouillés de leur empreinte auguste,
> Pouvoient cesser jamais de le manifester,
> Si Dieu n'existoit pas, il faudroit l'inventer."[1]

Nor is it only on this fundamental principle of religion that Voltaire, in his better days, delighted to enlarge. The existence of a natural law engraved on the human heart, and the liberty of the human will, are subjects which he has repeatedly enforced and adorned with all his philosophical and poetical powers. What can be more explicit, or more forcible, than the following exposition of the inconsistencies of fatalism?

> "Vois de la liberté cet ennemi mutin,
> Aveugle partisan d'un aveugle destin;
> Entends comme il consulte, approuve, ou délibére,
> Entends de quel reproche il couvre un adversaire,
> Vois comment d'un rival il cherche à se venger,
> Comme il punit son fils, et le veut corriger.
> Il le croyoit donc libre?—Oui sans doute, et lui-même
> Dément à chaque pas son funeste système.
> Il mentoit à son cœur, en voulant expliquer
> Ce dogme absurde à croire, absurde à pratiquer.
> Il reconnoit en lui le sentiment qu'il brave,
> Il agit comme libre et parle comme esclave."[2]

This very system, however, which Voltaire has here so severely reprobated, he lived to avow as the creed of his more advanced years. The words, indeed, are put into the mouth of a fictitious personage; but it is plain, that the writer meant to be understood as speaking his own sentiments. "Je vois une chaine immense, dont tout est chainon; elle embrasse, elle serre aujourd'hui la nature," &c. &c.

"Je suis donc ramené malgré moi à cette ancienne idée, que je vois être la base de tous les systèmes, dans laquelle tous les philosophes retombent apres mille detours, et qui m'est démontré par toutes les actions des hommes, par les miennes, par tous les événemens que j'ai lus, que j'ai vus, et aux-quelles j'ai eu part; c'est le Fatalisme, c'est la Necessité dont je vous ai deja parlé."—*(Lettres de Memmius à Ciceron.* See *Œuvres* de VOLTAIRE, *Mélanges,* Tome IV. p. 358. 4to. Edit. Geneve, 1771.)

"En effet" (says Voltaire, in another of his pieces), il seroit bien singulier que toute la nature, tous les astres, obeïssent à des lois éternelles, et qu'il y eut un petit animal haut de cinq pieds, qui au mépris de ces lois pût agir toujours comme il lui plairoit au seul gré de son caprice."

. . . . .To this passage Voltaire adds the following acknowledgment:—"L'ignorant qui pense ainsi n'a pas toujours pensé de même,[3] mais il est enfin contraint de se rendre."—*(Le Philosophe Ignorant.)*

Notwithstanding, however, this change in

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[1] A thought approaching very nearly to this occurs in one of Tillotson's Sermons. "The being of God is so comfortable, so convenient, so necessary to the felicity of mankind, that (as Tully admirably says) *Dii immortales ad usum hominum fabricati pene videantur.*—If God were not a necessary being of himself, he might almost be said to be made for the use and benefit of Man." For some ingenious remarks on this quotation from Cicero, see JORTIN'S *Tracts*, Vol. I. p. 371.

[2] These verses form a part of a *Discourse on the Liberty of Man;* and the rest of the poem is in the same strain. Yet so very imperfectly did Voltaire even then understand the metaphysical argument on this subject, that he prefixed to his Discourse the following advertisement. "On entend par ce mot *liberté*, le pouvoir de faire ce qu'on veut. Il n'y a, et ne peut y avoir d'autre *liberté*." It appears, therefore, that in maintaining the *liberty of spontaneity*, Voltaire conceived himself to be combating the scheme of Necessity; whereas *this* sort of liberty, no Necessitarian or Fatalist was ever hardy enough to dispute.

[3] In proof of this he refers to his *Treatise of Metaphysics*, written forty years before, for the use of Madame du Châtelet.

Voltaire's philosophical opinions, he continued to the last his zealous opposition to atheism.[1] But in what respects it is more pernicious than fatalism, it is not easy to discover.

A reflection of La Harpe's, occasioned by some strictures of Voltaire's upon Montesquieu, applies with equal force to the numberless inconsistencies which occur in his metaphysical speculations: "Les objets de méditation étoient trop etrangers à l'excessive vivacité de son esprit. Saisir fortement par l'imagination les objets qu'elle ne doit montrer que d'un côté, c'est ce qui est du Poete; les embrasser sous toutes les faces, c'est ce qui est du Philosophe, et Voltaire étoit trop exclusivement l'un pour être l'autre."—(*Cours de Litterat.* Tome XV. pp. 46, 47.)

A late author[2] has very justly reprobated that *spiritual deification of nature* which has been long fashionable among the French, and which, according to his own account, is at present not unfashionable in Germany. It is proper, however, to observe, that this mode of speaking has been used by two very different classes of writers; by the one with an intention to keep as much as possible the Deity out of their view, while studying his works; by the other, as a convenient and well understood metaphor, by means of which the frequent and irreverent mention of the name of God is avoided in philosophical arguments. It was with this last view, undoubtedly, that it was so often employed by Newton, and other English philosophers of the same school. In general, when we find a writer speaking of the *wise* or of the *benevolent intentions* of nature, we should be slow in imputing to him any leaning towards atheism. Many of the finest instances of Final Causes, it is certain, which the eighteenth century has brought to light, have been first remarked by inquirers who seem to have been fond of this phraseology; and of these inquirers, it is possible that some would have been less forward in bearing testimony to the truth, had they been forced to avail themselves of the style of theologians. These speculations, therefore, concerning the *intentions* or *designs of Nature*, how reprehensible soever and even absurd in point of strict logic the language may be in which they are expressed, may often be, nay, have often been, a step towards something higher and better; and, at any rate, are of a character totally different from the blind chance of the Epicureans, or the conflicting principles of the Manicheans

Note XX, p. 195.

"*In the attempt, indeed, which Kant has made to enumerate the general ideas which are not derived from experience, but arise out of the pure understanding, Kant may well lay claim to the praise of originality.*" The object of this problem is thus stated by his friend, Mr Schulze, the author of the Synopsis formerly quoted. (The following translation is by Dr Willich, *Elements*, &c. p. 45.)

"To investigate the whole store of original notions discoverable in our understanding, and which lie at the foundation of all our knowledge; and at the same time to authenticate their true descent, by showing that they are not derived from experience, but are pure productions of the understanding.

"1. The perceptions of objects contain, indeed, the matter of knowledge, but are in themselves blind and dead, and not knowledge; and our soul is merely passive in regard to them.

"2. If these perceptions are to furnish knowledge, the understanding must think of them, and this is possible only through notions (conceptions), which are the peculiar form of our understanding, in the same manner as space and time are the form of our sensitive faculty.

"3. These notions are active representations of our understanding-faculty; and as they regard *immediately* the perceptions of objects, they refer to the objects themselves only mediately.

"4. They lie in our understanding as pure notions *a priori*, at the foundation of all our knowledge. They are necessary forms, radical notions, categories (predicaments), of which all our knowledge of them must be compounded: And the table of them follows.

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[1] See the *Dict. Philosophique*, Art. *Athéisme.* See also the Strictures on the *Système de la Nature* in the *Questions sur l'Encyclopédie;* the very work from which the above quotation is taken.

[2] Frederick Schlegel. *Lectures on the History of Literature.* Vol. II. p. 169. Edinburgh, 1818.

"*Quantity;* unity, plurality, totality.

"*Quality;* reality, negation, limitation.

"*Relation;* substance, cause, reciprocation.

"*Modality;* possibility, existence, necessity.

"5. Now, to think and to judge is the same thing; consequently, every notion contains a particular form of judgment concerning objects. There are *four* principal *genera* of *judgments:* They are derived from the above four possible functions of the understanding, each of which contains under it *three species;* namely, with respect to

"*Quantity*, they are universal, particular, singular judgments.

"*Quality*, they are affirmative, negative, infinite judgments.

"*Relation*, they are categorical, hypothetical, disjunctive judgments.

"*Modality*, they are problematical, assertory, apodictical judgments."

These tables speak for themselves without any comment.

Note YY, p. 195.

Kant's notions of *Time* are contained in the following seven propositions: 1. *Idea temporis non oritur sed supponitur a sensibus.* 2. *Idea temporis est singularis*, non generalis. Tempus enim quodlibet non cogitatur, nisi tanquam pars unius ejusdem temporis immensi. 3. *Idea* itaque *temporis est intuitus*, et quoniam ante omnem sensationem concipitur, tanquam conditio respectuum in sensibilibus obviorum, est *intuitus*, non sensualis, sed *purus.* 4. *Tempus est quantum continuum* et legum continui in mutationibus universi principium. 5. *Tempus non est objectivum aliquid et reale*, nec substantia, nec accidens, nec relatio, sed subjectiva conditio, per naturam mentis humanæ necessaria, quælibet sensibilia, certa lege sibi coordinandi, et *intuitus purus.* 6. Tempus est conceptus verissimus, et, per omnia possibilia sensuum objecta, in infinitum patens, intuitivæ repræsentationis conditio. 7. Tempus itaque est *principium formale mundi sensibilis* absolute primum."

With respect to *Space*, Kant states a series of similar propositions, ascribing to it very nearly the same metaphysical attributes as to *Time*, and running as far as possible a sort of parallel between them. "A. *Conceptus spatii non abstrahitur a sensationibus externis.* B. *Conceptus spatii est singularis repræsentatio* omnia *in se* comprehendens, non *sub se* continens notio abstracta et communis. C. *Conceptus spatii itaque est intuitus purus;* cum sit conceptus singularis; sensationibus non conflatus, sed omnis sensationis externæ forma fundamentalis. D. *Spatium non est aliquid objectivi* et realis, nec substantia, nec accidens, nec relatio; sed *subjectivum* et ideale, e natura mentis stabili lege proficiscens, veluti schema, omnia omnino externe sensa sibi co-ordinandi. E. Quanquam *conceptus spatii*, ut objectivi alicujus et realis entis vel affectionis, sit imaginarius, nihilo tamen secius *respective ad sensibilia quæcunque*, non solum est *verissimus*, sed et omnis veritatis in sensualitate externa fundamentum."

These propositions are extracted from a Dissertation written by Kant himself in the Latin language.[1] Their obscurity, therefore, cannot be ascribed to any misapprehension on the part of a translator. It was on this account that I thought it better to quote them in his own unaltered words, than to avail myself of the corresponding passage in Born's Latin version of the *Critique of Pure Reason.*

To each of Kant's propositions concerning Time and Space I shall subjoin a short comment, following the same order in which these propositions are arranged above.

1. That the idea of *Time* has no resemblance to any of our sensations, and that it is, therefore, not derived from sensation immediately and directly, has been very often observed; and if nobody had ever observed it, the fact is so very obvious, that the enunciation of it could not entitle the author to the praise of much ingenuity. Whether "this idea be *supposed* in all our sen-

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[1] *De Mundi Sensibilis atque Intelligibilis forma et principiis.* Dissertatio pro loco professionis Log. et Metaph. Ordinariae rite sibi Vindicando; quam exigentibus statutis Academicis publice tuebitur Immanuel Kant.—Regiomonti, 1770.

sations," or (as Kant explains himself more clearly in his third proposition) "be *conceived* by the mind prior to all sensation," is a question which seems to me at least doubtful; nor do I think the opinion we form concerning it a matter of the smallest importance. One thing is certain, that this idea is an inseparable concomitant of every act of memory with respect to past events; and that, in whatever way it is acquired, we are irresistibly led to ascribe to the thing itself an existence independent of the will of any being whatever.

2. On the second proposition I have nothing to remark. The following is the most intelligible translation of it that I can give. "The idea of Time is singular, not general; for any particular length of Time can be conceived only as a part of one and the same immense whole."

3. From these premises (such as they are) Kant concludes, that the idea of time is *intuitive;* and that this intuition, being prior to the exercise of the senses, is not empirical but pure. The conclusion here must necessarily partake of the uncertainty of the premises from which it is drawn; but the meaning of the author does not seem to imply any very erroneous principle. It amounts, indeed, to little more than an explanation of some of his peculiar terms.

4. That Time is a *continued quantity* is indisputable. To the latter clause of the sentence I can annex no meaning but this, that time enters as an essential element into our conception of the law of continuity, in all its various applications to the changes that take place in Nature.

5. In this proposition Kant assumes the truth of that much contested, and, to me, incomprehensible doctrine, which denies the objective reality of time. He seems to consider it merely as a subjective *condition*, inseparably connected with the frame of the Human Mind, in consequence of which it arranges sensible phenomena, according to a certain law, in the order of succession.

6. What is meant by calling Time *a true conception*, I do not profess to understand; nor am I able to interpret the remainder of the sentence in any way but this, that we can find no limits to the range thus opened in our conceptions to the succession of sensible events.

7. The conclusion of the whole matter is, that Time is "absolutely the first formal principle of the sensible world." I can annex no meaning to this; but I have translated the original, word for word, and shall leave my readers to their own conjectures.

A. It appears from this, that, in the opinion of Kant, the idea of Space is connate with the mind, or at least, that it is prior to any information received from the senses. But this doctrine seems to me not a little doubtful. Indeed, I rather lean to the common theory, which supposes our first ideas of Space or Extension to be formed by abstracting this attribute from the other qualities of matter. The idea of Space, however, in whatever manner formed, is manifestly accompanied with an irresistible conviction, that Space is necessarily existent, and that its annihilation is impossible; nay, it appears to me to be also accompanied with an irresistible conviction, that Space cannot possibly be extended in more than three dimensions. Call either of these propositions in question, and you open a door to universal scepticism.

B. I can extract no meaning from this, but the nugatory proposition, that our conception of Space leads us to consider it as *the place* in which all things are comprehended.

C. "The conception of Space, therefore, is a *pure intuition*." This follows as a necessary corollary (according to Kant's own definition) from Prop. A. What is to be understood by the clause which asserts, that Space is the fundamental *form* of every external sensation, it is not easy to conjecture. Does it imply merely that the conception of *Space* is necessarily involved in all our notions of things external? In this case, it only repeats over, in different and most inaccurate terms, the last clause of Prop. B. What can be more loose and illogical than the phrase *external sensation?*

D. That Space is neither a *substance*, nor an *accident*, nor a *relation*, may be safely granted; but does it follow from this that it is nothing *objective*, or, in other words, that it is a mere creature of the imagination? This, however, would seem to be the idea of Kant; and yet I cannot reconcile it with what he says in Prop. E., that the conception of Space is the foundation of all the truth we ascribe to our perceptions of external objects. (The author's own words are—“omnis veritatis in sensualitate externa fundamentum!”)[1]

Upon the whole, it appears to me, that, among these various propositions, there are some which are quite unintelligible; that others assume, as first principles, doctrines which have been disputed by many of our most eminent philosophers; that others, again, seem to aim at involving plain and obvious truths in darkness and mystery; and that not one is expressed with simplicity and precision, which are the natural results of clear and accurate thinking. In considering time and space as the *forms* of all sensible phenomena, does Kant mean any thing more but this,—that we necessarily refer every sensible phenomenon to some point of space, or to some instant of time? If this was really his meaning, he has only repeated over, in obscurer language, the following propositions of Newton; “Ut ordo partium temporis est immutabilis, sic etiam ordo partium spatii. Moveantur hæc de locis suis, et movebuntur (ut ita dicam) de seipsis. *Nam tempora et spatia sunt sui ipsorum et rerum omnium quasi loca. In tempore, quoad ordinem successionis; in spatio, quoad ordinem situs locantur universa.* De illorum essentia est ut sint loca: et loca primaria moveri absurdum est.”

I have quoted this passage, not from any desire of displaying the superiority of Newton over Kant, but chiefly to show how very nearly the powers of the former sink to the same level with those of the latter, when directed to inquiries unfathomable by the human faculties. What abuse of words can be greater than to say, That neither the parts of time nor the parts of space can be *moved* from their *places*?[2] In the *Principia* of Newton, however, this incidental discussion is but a spot on the sun. In the *Critique of Pure Reason*, it is a fair specimen of the rest of the work, and forms one of the chief pillars of the whole system, both metaphysical and moral.

Note ZZ, p. 196.

The following quotation will account for the references which I have made to Mr Nitsch among the expounders of Kant's Philosophy. It will also serve to show that the *Critique of Pure Reason* has still *some* admirers in England, not less enthusiastic than those it had formerly in Germany.

“In submitting this fourth Treatise on the Philosophy of Kant to the reader” (says the author of these articles in the *Encyclopædia Londinensis*), “I cannot deny myself the satisfaction of publicly acknowledging the great assistance which I have derived in my literary pursuits, from my excellent and highly valued friend Mr Henry Richter. To him I am indebted for the clearness and perspicuity with which the thoughts of the immortal Kant have been conveyed to the public. Indeed, his comprehensive knowledge of the system, as well as his enthusiastic admiration of its general truth, render him a most able and desirable co-operator. Should, therefore, any good result to mankind from our joint labours in the display of this vast and profound system, he is justly entitled to his share of the praise. It is with sincere pleasure that I reflect upon that period, now two and twenty years ago, when we first studied together under the same master, Frederic Augustus Nitsch, who originally imported the seeds of TRANSCENDENTAL PHILOSOPHY from its native country, to plant them in our soil; and though, as is usually the case, many of those seeds were scattered by the wind, I trust that a sufficient number have taken root to maintain the growth of this vigorous and flourishing plant, till the time shall come, when, by its general cultivation, England may be enabled to enrich other nations with the most perfect specimens of its produce. Professor Nitsch, who thus bestowed upon our country her first attainments in the department of *Pure Science*, has paid the debt of nature. I confess it is some reflection upon England, that she did not foster and protect this immediate disciple of the father of philosophy; but the necessities of this learned and illustrious man unfortunately compelled him to seek that subsistence elsewhere, which was withheld from him here. At Rostock, about the year 1813, this valuable member of society, and perfect master of the philosophy he undertook to teach, entered upon his immortal career as a reward for his earthly services. It is with the most heartfelt satisfaction that I add my mite of praise to his revered memory. But for him, I might ever have remained in the dark regions of sophistry and uncertainty."

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[1] Mr Nitsch has remarked this difficulty, and has attempted to remove it. “The most essential objection (he observes) to Kant's system is, that it leads to scepticism; because it maintains, that the figures in which we see the external objects clothed are not inherent in those objects, and that consequently space is something *within*, and not without the mind.” (pp. 144, 145.) “It may be further objected (he adds), that, if there be no external space, there is also no external world. But this is concluding by far too much from these premises. If there be no external space, it will follow, that we are not authorised to assign *extension* to external things, but there will follow no more.” (p. 149.) Mr Nitsch then proceeds to obviate these objections; but his reply is far from satisfactory, and is indeed not less applicable to the doctrine of Berkeley than to that of Kant. This point, however, I do not mean to argue here. The concessions which Nitsch has made are quite sufficient for my present purpose. They serve at least to satisfy my own mind, that I have not misrepresented Kant's meaning.

[2] Was it not to avoid the palpable incongruity of this language that Kant was led to substitute the word *forms* instead of *places*; the former word not seeming to be so obviously inapplicable as the latter to time and space in common; or, to speak more correctly, being, from its extreme vagueness, equally unmeaning when applied to both?

NOTE A A A, p. 201.

Among the secondary mischiefs resulting from the temporary popularity of Kant, none is more to be regretted than the influence of his works on the habits, both of thinking and of writing, of some very eminent men, who have since given to the world histories of philosophy. That of Tenneman in particular (a work said to possess great merit) would appear to have been vitiated by this unfortunate bias in the views of its author. A very competent judge has said of it, that "it affords, as far as it is completed, the most accurate, the most minute, and the most rational view we yet possess of the different systems of philosophy; but that the critical philosophy being chosen as the vantage ground from whence the survey of former systems is taken, the continual reference in Kant's own language to his peculiar doctrines, renders it frequently impossible for those who have not studied the dark works of this modern Heraclitus to understand the strictures of the historian on the systems even of Aristotle or Plato." (See the article BRUCKER in the *Encyclopædia Britannica*, 7th Ed.) We are told by the same writer, that "among the learned of Germany, Brucker has never enjoyed a very distinguished reputation." This I can very easily credit; but I am more inclined to interpret it to the disadvantage of the German taste, than to that of the historian. Brucker is indeed not distinguished by any extraordinary measure of depth or of acuteness; but in industry, fidelity, and sound judgment, he has few superiors; qualities of infinitely greater value in the undertaker of a historical work, than that passion for systematical refinement, which is so apt to betray the best-intentioned writers into false glosses on the opinions they record.

When the above passage was written, I had not seen the work of Buhle. I have since had an opportunity of looking into the French translation of it, published at Paris in 1816; and I must frankly acknowledge, that I have seldom met with a greater disappointment. The account there given of the Kantian system, to which I turned with peculiar eagerness, has, if possible, involved to *my* apprehension, in additional obscurity, that mysterious doctrine. From this, however, I did not feel myself entitled to form an estimate of the author's merits as a philosophical historian, till I had read some other articles of which I considered myself better qualified to judge. The following short extract will, without the aid of any comment, enable such of my readers as know anything of the literary history of Scotland, to form an opinion upon this point for themselves.

"Reid n'attaqua les systèmes de ses prédécesseurs et notamment celui de Hume, que parce qu'il se croyait convaincu de leur défaut de fondement. Mais un autre antagoniste, non moins célèbre, du scepticisme de Hume, fut, en outre, guidé par la haine qu'il avoit vouée à son illustre compatriote, *lequel lui répondit avec beaucoup d'aigreur et d'animosité.* James Beattie, *professeur de morale à Edimbourg*, puis ensuite, de logique et de morale à l'Université d'Aberdeen, *obtint la préférence sur Hume lorsqu'il fut question de remplir la chaire vacante à Edimbourg*. Cette circonstance devint *sans doute* la principale source de l'inimitié que les deux savans conçurent l'un pour l'autre, et qui influa même sur le ton qu'ils employèrent dans les raisonnemens par lesquels ils se combattirent."—(Tome V. p. 235.)

To this quotation may I be pardoned for adding a few sentences relative to myself? "L'ouvrage de Dugald Stewart, intitulé, *Elements of the Philosophy of the Human Mind*, est un syncrétisme des opinions de Hartley et de Reid. Stewart borne absolument la connoissance, tant de l'âme que des choses extérieures, à ce que le sens commun nous en apprend, et croit pouvoir ainsi mettre l'étude de la métaphysique à l'abri du reproche de rouler sur des choses qui dépassent la sphère de notre intelligence, ou qui sont tout-a-fait inutiles dans la pratique de la vie........Les chapitres suivans renferment le développement du principe de l'association des idées. Ils sont presqu' entièrement écrits d'après Hartley. Stewart fait dériver de ce principe toutes les facultés intellectuelles et pratiques de l'homme."—(Tom. V. pp. 330, 331.)

Of the discrimination displayed by Buhle in the classification of systems and of authors, the title prefixed to his 19th chapter may serve as a specimen: "*Philosophy of Condillac, of Helvetius, of Baron d'Holbach, of Robinet, of Bonnet, of Montesquieu, of Burlemaqui, of Vattel, and of Reid.*"

But the radical defect of Buhle's work is, the almost total want of references to original authors. We are presented only with the general results of the author's reading, without any guide to assist us in confirming his conclusions when right, or in correcting them when wrong. This circumstance is of itself sufficient to annihilate the value of any historical composition.

Sismondi, in mentioning the history of modern literature by Bouterwek, takes occasion to pay a compliment (and, I have no doubt, a very deserved one) to German scholars in general; observing, that he has executed his task—"avec une étendue d'érudition, et une *loyauté* dans la maniere à en faire profiter ses lecteurs, qui semblent propres aux savans Allemands."—(*De la Litt. du Midi de l'Europe*, Tom. I. p. 13, à Paris, 1813.) I regret that my ignorance of the German language has prevented me from profiting by a work of which Sismondi has expressed so favourable an opinion; and still more, that the only history of philosophy from the pen of a contemporary German scholar, which I have had access to consult, should form so remarkable an exception to Sismondi's observation.

The contents of the preceding note lay me under the necessity, in justice to myself, of taking some notice of the following remark, by an anonymous critic, on the first part of this *Dissertation*, published in 1815.—(See *Quarterly Review*, Vol. XVII. p. 42.)

"In the plan which Mr Stewart has adopted, if he has not consulted his *strength*, he has at least consulted his *ease;* for, supposing a person to have the requisite talent and information, the task which our author has performed, is one which, with the historical abstracts of Buhle or Tenneman, cannot be supposed to have required any very laborious meditation."

On the insinuation contained in the foregoing passage, I abstain from offering any comment. I have only to say, that it was not till the summer of 1820 that I saw the work of Buhle; and that I have never yet had an opportunity of seeing that of Tenneman. From what I have found in the one, and from what I have heard of the other, I am strongly inclined to suspect, that when the anonymous critic wrote the above sentence, he was not less ignorant than myself of the works of these two historians. Nor can I refrain from adding (which I do with perfect confidence), that no person competent to judge on such a subject can read with attention this Historical Sketch, without perceiving that its merits and defects, whatever they may be, are at least all my own.

Note B B B, p. 204.

Of the Scottish authors who turned their attention to metaphysical studies, prior to the union of the two Kingdoms, I know of none so eminent as George Dalgarno of Aberdeen, author of two works, both of them strongly marked with sound philosophy, as well as with original genius. The one published at London, 1660, is entitled, "*Ars signorum, vulgo character universalis et lingua philosophica, qua poterunt homines diversissimorum idiomatum, spatio duarum septimanarum, omnia animi sui sensa (in rebus familiaribus) non minus intelligibiliter, sive scribendo, sive loquendo, mutuo communicare, quam linguis propriis vernaculis. Præterea, hinc etiam poterunt juvenes, philosophiæ principia, et veram logicæ praxin, citius et facilius multo imbibere, quam ex vulgaribus philosophorum scriptis.*" The other work of Dalgarno is entitled, "*Didascolocophus, or the Deaf and Dumb Man's Tutor.*" Printed at Oxford, 1680. I have given some account of the former in the notes at the end of the first volume of the *Philosophy of the Human Mind;* and of the latter, in a *Memoir*, published in Vol. VII. of the *Transactions of the Royal Society of Edinburgh.* As they are now become extremely rare, and would together form a very small octavo volume, I cannot help thinking that a bookseller, who should reprint them, would be fully indemnified by the sale. The fate of Dalgarno will be hard indeed, if, in addition to the unjust neglect he experienced from his contemporaries, the proofs he has left of his philosophical talents shall be suffered to sink into total oblivion.

Lord Stair's *Physiologia Nova Experimentalis* (published at Leyden in 1686) is also worthy of notice in the literary history of Scotland. Although it bears few marks of the eminent talents which distinguished the author, both as a lawyer and as a statesman, it discovers a very extensive acquaintance with the metaphysical as well as with the physical doctrines, which were chiefly in vogue at that period; more particularly with the leading doctrines of Gassendi, Descartes, and Malebranche. Many acute and some important strictures are made on the errors of all the three, and at the same time complete justice is done to their merits; the writer every where manifesting an independence of opinion and a spirit of free inquiry, very uncommon among the philosophers of the seventeenth century. The work is dedicated to the Royal Society of London, of the utility of which institution, in promoting experimental knowledge, he appears to have been fully aware.

The limits of a note will not permit me to enter into farther details concerning the state of philosophy in Scotland, during the interval between the union of the Crowns and that of the Kingdoms. The circumstances of the country were indeed peculiarly unfavourable to it. But memorials still exist of a few individuals, sufficient to show, that the philosophical taste, which has so remarkably distinguished our countrymen during the eighteenth century, was in some measure an inheritance from their immediate predecessors. Leibnitz, I think, somewhere mentions the number of learned Scotchmen by whom he was visited in the course of their travels. To one of them (Mr Burnet of Kemney) he has addressed a most interesting letter, dated in 1697, on the general state of learning and science in Europe; opening his mind on the various topics which he introduces, with a freedom and confidence highly honourable to the attainments and character of his correspondent. Dr Arbuthnot, who was born about the time of the Restoration, may serve as a fair specimen of the very liberal education which was then to be had in some of the Scottish Universities. The large share which he is allowed to have contributed to the *Memoirs of Martinus Scriblerus* abundantly attests the variety of his learning, and the just estimate he had formed of the philosophy of the schools; and in one or two passages, where he glances at the errors of his contemporaries, an attentive and intelligent reader will trace, amid all his pleasantry, a metaphysical depth and soundness which seem to belong to a later period.—Is there no Arbuthnot now, to chastise the follies of our craniologists?

Note C C C, p. 214.

The letter which gives occasion to this note was written twenty years after the publication of the *Treatise of Human Nature.* As it relates, however, to the history of Mr Hume's studies previous to that publication, I consider this as the proper place for introducing it. The Dialogue to which the letter refers was plainly that which appeared after Mr Hume's death, under the title of *Dialogues on Natural Religion.*

" *Ninewells, March* 19. 1751.

" Dear Sir—You would perceive by the sample I have given you, that I make Cleanthes the hero of the dialogue. Whatever you can think of to strengthen that side of the argument will be most acceptable to me. Any propensity you imagine I have to the other side crept in upon me against my will; and it is not long ago that I burned an old manuscript book, wrote before I was twenty, which contained, page after page, the gradual progress of my thoughts on that head. It begun with an anxious search after arguments to confirm the common opinion; doubts stole in, dissipated, returned, were again dissipated, returned again, and it was a perpetual struggle of a restless imagination against inclination, perhaps against reason.

" I have often thought that the best way of composing a dialogue would be for two persons that are of different opinions about any question of importance, to write alternately the different parts of the discourse, and reply to each other. By this means that vulgar error would be avoided of putting nothing but nonsense into the mouth of the adversary; and, at the same time, a variety of character and genius being upheld, would make the whole look more natural and unaffected. Had it been my good fortune to live near you, I should have taken on me the character of Philo in the dialogue, which you'll own I could have supported naturally enough; and you would not have been averse to that of Cleanthes. I believe, too, we could both of us have kept our tempers very well; only you have not reached an absolute philosophical indifference on these points. What danger can ever come from ingenious reasoning and inquiry? The worst speculative sceptic ever I knew was a much better man than the best superstitious devotee and bigot. I must inform you too, that this was the way of thinking of the ancients on this subject. If a man made profession of philosophy, whatever his sect was, they always expected to find more regularity in his life and manners than in those of the ignorant and illiterate. There is a remarkable passage of Appian to this purpose. That historian observes, that, notwithstanding the established prepossession in favour of learning, yet some philosophers who have been trusted with absolute power have very much abused it; and he instances in Critias, the most violent of the Thirty, and Aristion, who governed Athens in the time of Sylla. But I find, upon inquiry, that Critias was a professed Atheist, and Aristion an Epicurean, which is little or nothing different; and yet Appian wonders at their corruption as much as if they had been Stoics or Platonists. A modern zealot would have thought that corruption unavoidable.

" I could wish that Cleanthes's argument could be so analysed as to be rendered quite formal and regular. The propensity of the mind towards it, unless that propensity were as strong and universal as that to believe in our senses and experience, will still, I am afraid, be esteemed a suspicious foundation. 'Tis here I wish for your assistance. We must endeavour to prove that this propensity is somewhat different from our inclination to find our own figures in the clouds, our face in the moon, our passions and sentiments even in inanimate matter. Such an inclination may and ought to be controlled, and can never be a legitimate ground of assent.

" The instances I have chosen for Cleanthes are, I hope, tolerably happy; and the confusion in which I represent the sceptic seems natural. But, *si quid novisti rectius*, &c.

" You ask me, *if the idea of cause and effect is nothing but vicinity?* (you should have said constant vicinity or regular conjunction)—*I would gladly know whence is that farther idea of causation against which you argue?* The question is pertinent; but I hope I have answered it. We feel, after the constant conjunction, an easy transition from one idea to the other, or a connection in the imagination; and, as it is usual for us to transfer our own feelings to the objects on which they are dependent, we attach the internal sentiment to the external objects If no single instances of cause and effect appear to have any connection, but only repeated similar ones, you will find yourself obliged to have recourse to this theory.

"I am sorry our correspondence should lead us into these abstract speculations. I have thought, and read, and composed very little on such questions of late. Morals, politics, and literature, have employed all my time; but still the other topics I must think more curious, important, entertaining, and useful, than any geometry that is deeper than Euclid. If, in order to answer the doubts started, new principles of philosophy must be laid, are not these doubts themselves very useful? Are they not preferable to blind and ignorant assent? I hope I can answer my own doubts; but, if I could not, is it to be wondered at? To give myself airs and speak magnificently; might I not observe that Columbus did not conquer empires and plant colonies?

"If I have not unravelled the knot so well in these last papers I sent you, as perhaps I did in the former, it has not, I assure you, proceeded from want of good will. But some subjects are easier than others; and sometimes one is happier in one's researches and inquiries than at other times. Still I have recourse to the *si quid novisti rectius;* not in order to pay you a compliment, but from a real philosophical doubt and curiosity."[1]

An unfinished draught of the letter to which the foregoing seems to have been the reply, has been preserved among Sir Gilbert Elliot's papers. This careless fragment is in his own handwriting, and exhibits an interesting specimen of the progress made in Scotland among the higher classes, seventy years ago, not only in sound philosophy, but in purity of English style.

"Dear Sir—Inclosed I return your papers, which, since my coming to town, I have again read over with the greatest care. The thoughts which this last perusal of them has suggested I shall set down, merely in compliance with your desire, for I pretend not to say anything new upon a question which has already been examined so often and so accurately. I must freely own to you, that to me it appears extremely doubtful, if the position which Cleanthes undertakes to maintain can be supported, at least in any satisfactory manner, upon the principles he establishes and the concessions he makes. If it be only from effects exactly similar that experience warrants us to infer a similar cause, then I am afraid it must be granted, that the works of Nature resemble not so nearly the productions of man as to support the conclusion which Cleanthes admits can be built only on that resemblance. The two instances he brings to illustrate his argument are indeed ingenious and elegant; the first, especially, which seemingly carries great weight along with it: the other, I mean that of the Vegetating Library, as it is of more difficult apprehension, so I think it is not easy for the mind either to retain or to apply it. But, if I mistake not, this strong objection strikes equally against them both. Cleanthes does no more than substitute two artificial instances in the place of natural ones: but if these bear no nearer a resemblance than natural ones to the effects which we have experienced to proceed from men, then nothing *can* justly be inferred from them; and if this resemblance be greater, then nothing farther *ought* to be inferred from them. In one respect, however, Cleanthes seems to limit his reasonings more than is necessary even upon his own principles. Admitting, for once, that experience is the only source of our knowledge, I cannot see how it follows, that, to enable us to infer a similar cause, the effects must not only be similar, but exactly and precisely so. Will not experience authorise me to conclude, that a machine or piece of mechanism was produced by human art, unless I have happened previously to see a machine or piece of mechanism exactly of the same sort? Point out, for instance, the contrivance and end of a watch to a peasant, who had never before seen any thing more curious than the coarsest instruments of husbandry, will he not immediately conclude, that this watch is an effect produced by human art and design? And

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[1] The original is in the possession of the Earl of Minto.

I would still farther ask, does a spade or a plough much more resemble a watch than a watch does an organised animal? The result of our whole experience, if experience indeed be the only principle, seems rather to amount to this: There are but two ways in which we have ever observed the different parcels of matter to be thrown together; either at random, or with design and purpose. By the first we have never seen produced a regular complicated effect, corresponding to a certain end; by the second, we uniformly have. If, then, the works of nature, and the productions of man, resemble each other in this one general characteristic, will not even experience sufficiently warrant us to ascribe to both a similar though proportionable cause? If you answer, that abstracting from the experience we acquire in this world, order and adjustment of parts is no proof of design, my reply is, that no conclusions, drawn from the nature of so chimerical a being as man, considered abstracted from experience, can at all be listened to. The principles of the human mind are clearly so contrived as not to unfold themselves till the proper objects and proper opportunity and occasion be presented. There is no arguing upon the nature of man but by considering him as grown to maturity, placed in society, and become acquainted with surrounding objects. But if you should still farther urge, that, with regard to instances of which we have no experience, for aught we know, matter may contain the principles of order, arrangement, and the adjustment of final causes, I should only answer, that whoever can conceive this proposition to be true, has exactly the same idea of matter that I have of mind. I know not if I have reasoned justly upon Cleanthes's principles, nor is it indeed very material. The purpose of my letter is barely to point out what to me appears the fair and philosophical method of proceeding in this inquiry. That this universe is the effect of an intelligent designing cause, is a principle which has been most universally received in all ages and in all nations; the proof uniformly appealed to is, the admirable order and adjustment of the works of nature. To proceed, then, experimentally and philosophically, the first question in point of order seems to be, what is the effect which the contemplation of the universe, and the several parts of it, produces upon a considering mind? This is a question of fact; a popular question, the discussion of which depends not upon refinements and subtlety, but merely upon impartiality and attention. I ask, then, what is the sentiment which prevails in one's mind, after having considered not only the more familiar objects that surround him, but also all the discoveries of Natural Philosophy and Natural History; after having considered not only the general economy of the universe, but also the most minute parts of it, and the amazing adjustment of means to ends with a precision unknown to human art, and in instances innumerable? Tell me (to use the words of Cleanthes), does not the idea of a contriver flow in upon you with a force like that of sensation? Expressions how just! (yet in the mouth of Cleanthes you must allow me to doubt of their propriety.) Nor does this conviction only arise from the consideration of the inanimate parts of the creation, but still more strongly from the contemplation of the faculties of the understanding, the affections of the heart, and the various instincts discoverable both in men and brutes; all so properly adapted to the circumstances and situation both of the species and the individual. Yet this last observation, whatever may be in it, derives no force from experience. For who ever saw a mind produced? If we are desirous to push our experiments still farther, and inquire, whether the survey of the universe has regularly and uniformly led to the belief of an intelligent cause? Shall we not find, that, from the author of the book of Job to the preachers at Boyle's Lecture, the same language has been universally held? No writer, who has ever treated this subject, but has either applied himself to describe, in the most emphatical language, the beauty and order of the universe, or else to collect together and place in the most striking light, the many instances of contrivance and design which have been discovered by observation and experiment. And when they have done this, they seem to have imagined that their task was finished, and their demonstration complete; and indeed no wonder,—for it seems to me, that we are scarce more assured of our own existence, than that this well-ordered universe is the effect of an intelligent cause.

"This first question, then, which is indeed a question of fact, being thus settled upon observations which are obvious and unrefined, but not on that account the less satisfactory, it becomes the business of the philosopher to inquire, whether the conviction arising from these observations be founded on the conclusions of reason, the reports of experience, or the dictates of feeling, or possibly upon all these together; but if his principles shall not be laid so wide as to account for the fact already established upon prior evidence, we may, I think, safely conclude, that his principles are erroneous. Should a philosopher pretend to demonstrate to me, by a system of optics, that I can only discern an object when placed directly opposite to my eye, I should certainly answer, your system must be defective, for it is contradicted by matter of fact."—

END OF THE FIRST DISSERTATION.

DISSERTATION SECOND:

EXHIBITING A GENERAL VIEW

OF THE

PROGRESS OF ETHICAL PHILOSOPHY

CHIEFLY

DURING THE SEVENTEENTH AND EIGHTEENTH CENTURIES.

BY THE RIGHT HONOURABLE

SIR JAMES MACKINTOSH, LL.D., F.R.S., M.P.

WITH

A PREFACE

BY

WILLIAM WHEWELL, D.D.,

MASTER OF TRINITY COLLEGE, AND PROFESSOR OF MORAL PHILOSOPHY IN THE
UNIVERSITY OF CAMBRIDGE.

DISSERTATION SECOND.

ADVERTISEMENT.

In publishing a new edition of the *Encyclopædia Britannica*, the Proprietors think themselves fortunate in being able to accompany the following Dissertation with a Preface which presents a succinct and comprehensive view of its leading objects and doctrines. As allusion is there made to the "irregular and interrupted manner" in which it was written, and to the want of any notice of the recent Ethical speculations of the Continental Philosophers, it may be proper, in justice to the very eminent author, to lay before the reader the following history of its composition, as given in the interesting Memoirs of his Life, lately published by his Son.

"The late Mr Dugald Stewart and Mr Playfair had agreed to furnish Dissertations, the one on the history of Metaphysical, Ethical, and Political Philosophy, the other on the history of Mathematical and Physical Science, to be prefixed to the *Supplement* to the *Encyclopædia Britannica.* The design was not completed by either of those illustrious writers. Both died before their respective portions of it were finished. The history of the mathematical and physical sciences, by the latter, was brought down to the period marked by the discoveries of Newton and Leibnitz; and the history of metaphysical philosophy was, by the former, brought down to the close of the last century. In treating this great branch of his subject, Mr Stewart has occasionally adverted to the kindred branches of ethics and politics; but there was wanting to the completion of his design a full view of the progress of opinion in those sciences, particularly during the eighteenth century. In 1828, a new and improved edition of the *Encyclopædia*, being the seventh, was projected, and it was a part of the Editor's plan for the improvement of this edition, to continue the magnificent historical Dissertations that had been published with the *Supplement*, and to prefix the whole, in their completed form, to this edition of the principal work. A proposal to write a Dissertation in continuation of that of Mr Stewart upon the Ethical and Political Philosophy of the last century, was, in August 1828, accordingly made to Sir James, by the Editor, Mr Macvey Napier. Having already resolved to devote the remainder of his labours to British history, he had considerable difficulty in acceding to the proposal. But his love of the subject, his natural wish to preserve some of his early reading and reflections, and the entreaties of Mr Napier, who had a few years before been introduced to him by Mr Stewart, and with whom he was in the habit of corresponding, prevailed over his scruples, and an agreement in consequence took place for the execution of an historical Dissertation, embracing this object, and extending over the period that had been left untouched by his predecessor. It had originally been agreed, as above stated, that the Dissertation should include political as well as ethical philosophy, but the author's uncertain health, and the parliamentary duties of an interesting crisis, occasioned the abandonment of this part of the plan, and even obliged him to omit the history of the ethical philosophy of the Continent.

" In a letter to Mr Napier, dated in January 1829, he says, ' I am now reconciled to my labour by a new rising hope, that it may enable me to make some of the contributions to Ethics which, in more ambitious days, I presumed to expect would have been more extensive.' And in another letter, written about the same time, he thus expresses himself: ' You will see I have made some (I hope useful) additions to one of the sections, and I would have made more, if I could have afforded the time. But alas! I have none to spare; otherwise, I like this sort of work much better than any other. Speaking of his progress, a little afterwards, he says, ' I begin to hope well of my discourse, which I endeavour to make a development of ethical principles, as they historically arose—a new attempt in our language.'

" Again, he thus adverts to the section on Bishop Butler then just finished :—' The part in which I think I have done most service, is that in which I have endeavoured to slip in a foundation under Butler's doctrine of the supremacy of conscience, which he left baseless.'—When he came, in April 1829, to fear that it would be necessary to abandon all notice, not only of the progress of political philosophy, but also of the ethical philosophy of the Continent, he expressed great regret at the probable omission of this last section. ' I shall be quite sorry,' he said, ' if time should require the omission of the continental part, which would be the newest of the whole.'

" No one could be more thoroughly aware than himself of the imperfections that must attach to a work on such a subject, written by snatches, and amidst such frequent and sometimes distressing interruptions; and he accordingly mentions that it was very earnestly his wish ' to leave an addition of it, with such improvements as time, criticism, conversation, and reflection might suggest.' This very natural wish he unfortunately did not live long enough to have an opportunity afforded him of carrying into execution."

DISSERTATION SECOND.

PREFACE BY WILLIAM WHEWELL, D.D.

A History of the Philosophy of Morals may, for many purposes, be considered as forming a large portion of the Philosophy itself; and probably, to most readers, the portion which is by far the most agreeable. The writer of such a history, if it be worthy the name, must present all that has been done by the moralists of preceding times as steps in a progress; and must thus be led to point out the ultimate position which the subject has in his own day assumed.

The history of ethical speculations which the following Dissertation contains, has, however, not only the merit of exhibiting the present condition of ethical philosophy, but has also a peculiar advantage in the point of view from which the subject is regarded; since the author's opinions were, in the main, those to which the most moderate and popular writers of his own country had generally been led, and which had therefore most influenced general literature and common reasonings. A view of Moral Philosophy written in such a spirit, escapes, and may in some measure correct, the exaggerations and paradoxes of new and immature theories.

Some of Mackintosh's views were peculiarly his own, but much of his system of opinions was adopted from the doctrines of the great philosophers whom he here reviews. Perhaps some light may be thrown on the following Dissertation, by stating the main points of both kinds, as they may be collected from the work itself; and this will be in some measure done in the present preface. Also, as the ethical system embraced by Mackintosh included some tenets which have in our own time been the subject of much controversy, and on which it appears to me that errors have been widely prevalent, I have ventured to make a few remarks, such as I thought most fitted to put the doctrines in their proper point of view. I may add, that as my author's survey is in a great measure restricted to British writers, I have not thought myself called on to take note of the direction which ethical speculations have recently assumed in France and Germany, or of the indications which have appeared in the literature of our own country of the influence of these foreign impulses.

The views which Mackintosh entertained, and which were peculiarly the result of his own reasonings, are delivered in various parts of the Dissertation, but will perhaps become more intelligible by being stated as they are to be collected from the whole. The work was written in an irregular and interrupted manner; a circumstance which introduced many repetitions, and a mixture of the didactic with the historical portions, which may have given rise to some confusion.

I. The first main point in Mackintosh's view of ethics, is his opinion, that those which are usually termed the benevolent affections (as, for example, parental love and compassion) are properly described as *disinterested*. This doctrine he notices as one of the valuable truths which Butler brought clearly into view (p. 360); and he attaches to it so much consequence, that, in concluding his Dissertation (p. 432), he declares himself ready to relinquish his theory, if it be prôved to be at variance with the reality of the social affections, which he there speaks of as the most indisputable and the most important part of human nature.

Opinions opposite to this have been asserted in various forms: some, for instance, have said, that the affections are all merely forms of self-love; or that they are selfish; or that they really regard self; or have professed to deduce them from some selfish principle, as Hobbes from the love of power. A few remarks may here suffice on each of these modifications of the selfish system.

(1.) Butler, and after him other writers, as well as Mackintosh, wish, for the sake of clearness, to confine the application of the term *self-love* to that cool and prudential regard to our own welfare which weighs and estimates the chances and means of happiness; and which is thus distinct from the passions and affections which impel us to action immediately, without intervening reflection or calculation of consequences. It will probably be universally allowed, that gratitude or pity, friendship or filial love, are clearly distinct from self-love, *in this sense*. The term self-love has been objected to altogether by some persons, and Mackintosh himself appears to be dissatisfied with it (p. 422). Yet it seems to be not unapt to describe that state of mind in which we regard ourselves as external and detached objects of solicitude, and provide for our own wellbeing, as we would do for that of a friend whose passions we can resist, and whose future and permanent good we try to secure, without losing our calmness of feeling and clearness of view. The self-love which aims at our own welfare in such a temper may make us do kind actions; but it is, in itself, broadly distinguished from kindness and love of other persons.

But further, it is argued by Butler and Mackintosh, that not only the benevolent affections, but the *appetites* also, are clearly distinguishable from *this* self-love. A man may, as Butler says, eat from self-love, out of a regard to his health; he may also eat from the appetite of hunger; but the grounds of action are plainly different in the two cases. The gratification which results from the act does not make it an act of self-love. And just as little, they urge, does the gratification which accompanies the exercise of the domestic, or any other benevolent affections, justify us in ascribing them to such self-love as we have described.

(2.) As the object of the appetites is something different from ourselves and our own feelings, the object of the benevolent desires is so too. As food is the object of hunger, the gratification or the wellbeing of the child is the object of parental affection. The pleasure which results when the object is attained is not the aim of the agent, for it does not enter into his contemplation; nor could we derive pleasure from the attainment of such objects except the desire had previously existed (pp. 360, 364). In conformity with this view, it is maintained by the writers of this school, that neither the appetites nor the desires can properly be called *selfish*. (*Stewart, Outlines of Moral Philosophy*, p. 86.)

The term *selfish*, which is, I think, not used by Butler in the part of his works now referred to, is, however, that about which the controversy on this subject has generally raged most hotly. In opposition to the opinion just stated, it has often been said, that the desire of power, of wealth, of superiority, of esteem, are selfish principles.

If it be contended that these desires (and the benevolent affections for the same reason) are selfish because they are felt *by* self, Mackintosh answers (p. 360), that acts of the understanding, and processes of reasoning, might be called selfish on the same ground. But it is easily seen that something different from this is usually meant by the assertion. When it is popularly contended that the love of fame, for instance, is a selfish principle of action, it is generally implied that this affection is more selfish than to common eyes it appears. The assertor gives himself credit for having analysed the motive in question into elements not immediately obvious;—for discerning that a feeling, which at first appears to have an elevated and exterior aim, has, in fact, latently, a reflex view and a lower object. The disposition which men have to be pleased with such attempts at the dissection of motives into baser elements, is widely prevalent: it is this disposition, for instance, which has given to the Maxims of La Rochefoucauld their charm and their popularity.

But the flashes of the epigrammatist, whatever applause they may excite, are not likely to be of much use as a light to the philosophical reasoner; and the question, What motives can properly be called *selfish*, as a point of moral philosophy, must be decided in a very different spirit. Now, the popular disposition to detect selfishness in human motives is obviously accompanied by a depreciating estimate of the feelings in which this taint is perceived. But this disapproval, in spite of the conceit and ill-nature in which it may originate, manifestly implies a belief that men's feelings may be, and ought to be, other than selfish; for how can we contemn a person for having selfish feelings only, if human nature admits of no others? The common application of the term *selfish*, implies a moral disapprobation as well as a metaphysical analysis. We endeavour in vain to dissolve this association; and yet, so long as it subsists, it is plain that the condemnation which we pronounce in some cases, implies the possibility of cases in which it is not deserved. If we despise the love of fame as a selfish motive, we reserve our admiration for motives of a different class. The emphasis with which we apply the term, implies that it is not universally applicable. But when we assert, as a universal philosophical truth, that all our affections are selfish, we employ the word in a technical manner, distinct from its common use. Now, where is the advantage to philosophy of telling us that our love of parents and friends, that our gratitude and compassion, are selfish feelings, if the assertion be true only when the word is used in a sense different from the common one? The paradox startles us; when explained, it ceases to shock; but why incur the necessity of such an explanation? It must be allowed that such affections as I have just mentioned deserve and attract our love and approbation as much as any feelings can do? why, then, use terms which seem fitted only to direct towards them our disapproval and aversion?

We may add, with Brown (*Lectures*, vol. iv., p. 63), that if the benevolent and virtuous affections are to be called selfish, it will be necessary to form two divisions of selfish actions;—one containing those selfish actions in which self is the direct object; the other containing those very different selfish actions which are usually called disinterested. Till it is seen what advantage would be gained by this new nomenclature, it is surely better to use terms in their usual sense.

It is not easy to fix precise limits to the use of the term selfish, which thus denotes, not a positive philosophical attribute, but a comparative quality, to which some blame inevitably clings. Mackintosh says well (p. 360), "The weakness of the social affections, and the strength of the private desires, properly constitute selfishness." And Stewart (*Outlines*, p. 114) gives nearly the same account of this word, which he illustrates by saying, "Though we apply the epithet selfish to avarice, and to low and private sensuality, we never apply it to the desire of knowledge, or to the pursuits of virtue, which are certainly sources of more exquisite pleasures than riches or sensuality can bestow."

(3.) That the benevolent affections, in their usual form, have not self for their immediate *object*, is so evident that it needs hardly to be insisted on. In what sense can the mother who unhesitatingly exposes her life to save that of her child, be said to regard herself, of whom she never once thinks? In what way does Desdemona act from self-regard, when, in the very article of death, she endeavours to shelter the reputation of the husband who murders her?[1] To speak of self as the object of the regard or contemplation of the person acting in such instances, or in any instances in which the action proceeds directly from the benevolent affections, is to deprive words and phrases of all distinct and intelligible meaning and use.

(4.) When any particular theory is propounded, by which the results of the benevolent affections are traced to some remote interested principle, a refutation of the theory is readily suggested by a consideration of the common characteristic circumstances of the affections. Thus, with regard to Hobbes' system—that the affections have their origin in the love of power—Butler answers briefly, but satisfactorily, that such an hypothesis does not lead us to anything at all resembling the known state of the case;—that we wish good to others quite independently of our being ourselves the authors of it;—that we make distinctions among the objects of our good-will, where the love of power would make no difference;—that the love of power would be gratified by doing harm as well as good, and that thus cruelty and benevolence would be the same affection. (Sermon I, Note; and the following Dissertation, p. 337.) And if it were proposed to reduce the benevolent affections to any other system of original principles and associations of thought, it might be answered, that if these supposed original principles involve the desire of any besides physical pleasures (as the desire of wealth, power, dignity), they themselves require analysis, at least as much as the affections. It is at least, as possible to love a father, as it is to desire his estate; and the greatest good that the estate can procure us, can hardly consist of anything more intelligible than filial love. Nor would such an hypothesis avail us; for the affections are, in the greater number of cases, far stronger than any aggregation of such supposed elements would make them. To what purpose do we associate ideas with the desire of wealth, power, and dignity, in order to form the family affections, if we are compelled to allow that the whole feeling thus produced is greater than the sum of all its parts? To claim philosophical merit for such an analysis of the disinterested emotions into the effects of association of ideas, is to deprive the terms Association and Analysis of all meaning. Or how are our benevolent affections accounted for by the need we have of our friends as means, if this regard to the means be both much stronger and much more distinctly intelligible than the regard to the ends can ever become? Does not this shew that, in fact, the hypothetical end is not *our* end?

On such grounds, Mackintosh and other writers appear to do well in arranging the benevolent affections as a class of principles of action distinct from the desire of power, superiority, and the like. Those are not capable of being analysed into these, and we are sensible of an insurmountable incongruity when the two classes are brought into comparison. If the love of a parent be a compound of love, of power, and similar ingredients, will it not follow, that if we expect to gain power by sacrificing a parent rather than by serving him, it is *consistent with the nature* of our best affections that we should do so? And is not this a conclusion too monstrous to be accepted by any moralist? The benevolent and family affections, and the desire of power, appear, then, to differ in some other way than in being modifications of the same elements; and, even if we choose (unphilosophically as it has appeared) to call the latter class of principles selfish, the former must be arranged in a different group, which we cannot designate better than by calling them disinterested.

II. The next leading principles of Mackintosh's philosophy are, the independent *existence* and the *supremacy* of the conscience or moral faculty. Here also he ascribes to Butler the merit of having first brought these doctrines into a clear light (p. 361); though Hutcheson, who had somewhat of a steadier view of this faculty, gave it the name of the *moral sense.*

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[1] *Desdemona.* A guiltless death I die.
Emilie. O who hath done
This deed?
Desdemona. Nobody; I myself; farewell;
Commend me to my kind lord; O farewell.—(*Dies.*)

The question of the moral sense has been much discussed since Butler's time. It is not necessary here to go fully into this controversy, but I may be allowed to make a few remarks on some of the arguments connected with the following Dissertation.

(1.) In the first place, as to the *existence* of the moral faculty. It is allowed on all sides that we have a conception of moral obligation; and the question is, Whether this conception can be resolved into some operation of the intellectual faculties, as the perception of general utility; or whether, on the contrary, it is incapable of being thus resolved, and must properly be ascribed to a separate faculty.

It will readily appear that the discussion of this question must be attended by great difficulties, for we cannot easily find a test to determine, or terms to express, the identity or the difference of our perceptions of the useful and the right. These internal perceptions can only be described by means of analogical and metaphorical language; and this must discharge its office very imperfectly. Even with respect to external senses, where the meaning of our terms is naturally much more clear and palpable, an exact treatment of such questions is far from easy. We cannot, by mere language, convey a conception of the difference of sights and sounds. Is the perception of form a different faculty from the perception of colour? This question has been found extremely perplexing; we may therefore be certain that the question of the distinct existence of the moral faculty will require great clearness and steadiness of thought for its solution.

But still the question does not seem to be incapable of answer. Do we mean the same thing when we say that an action is right, and when we say that it is, on the whole, and taken in all its consequences, useful? It must be observed, that the question is not, Whether right actions *are*, on the whole, useful; for that we will suppose to be granted; but it is, Whether, by describing them as right, *we mean* nothing more than that we believe them to be useful? If by *right*, and by equivalent words, we intend some quality and attribute which *useful* and similar terms do not express, we must have the faculty of conceiving such a quality; and this faculty is the moral sense. Such a faculty Butler, and after him many modern writers, including Mackintosh, hold to be part of human nature. The following are some of the grounds for his opinion:

(2.) The words which express what is morally right, and the related ideas, cannot be replaced by any different set of terms. Right, duty, what we ought to do, are not expressed to the satisfaction of any one by any phraseology borrowed from the consideration of consequences. They are as untranslatable into the language which contemplates utility alone, as the names of colours are incapable of being expressed by those denoting the properties of space. When I say that an act is my duty, that it is right, I give an entire assent to the rule which commands me to do it, whatever be the consequences.[1] It may be true that all acts of duty are, taken in all their consequences, useful; but assuredly this is not what we mean, this is not the quality we ascribe to them, by the use of such terms.

Perhaps the most distinctive of these terms is the word *ought*, and the corresponding words which occur in all languages. It is universally felt that when we say, in a moral sense, that we ought to do any action, we mean something different from saying it is advantageous in its consequences. This word *ought*, which, as Mackintosh says "most perfectly denotes duty," appears to be the simplest and most universal expression of the moral sense.

(3.) The impossibility of wresting this word, *ought*, to the side of the utilitarian theory, may, I think, be inferred from the amusing vehemence with which Mr Bentham endeavours to expel it from his territory. "The talisman of arrogance, indolence, and ignorance, is to be found in a single word, an authoritative imposture, which in these pages it will be frequently necessary to unveil. It is the word 'ought,' 'ought or ought not,' as circumstances may be.

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[1] Whewell's Elements of Morality, Art. 73. (2d Edition.)

In deciding you ought to do this, you ought not to do it, is not every question of morals set at rest?

"If the use of the word be admissible at all, it 'ought' to be banished from the vocabulary of morals." (*Deontology*, vol. i., p. 32.)[1]

Till this is done, he proposes to neutralise this obnoxious term by the use of another potent word—'why?'

It is clear that the reason why the word so frequently occurs to excite Mr Bentham's displeasure is, that it refers to a universal and unavoidable aspect of actions, which men constantly recognise, and cannot help expressing in the words they familiarly employ. And Mr Bentham's "why" involves an assumption no less dogmatical than that of which he complains; for by it he intends to prescribe that the answer shall be in no other language than that of the utilitarian theory.

(4.) The unavoidable occurrence of the conception implied in the word *ought*, notwithstanding that it resists the attempt at analysis of which we have just spoken, may be inferred from its use by those whose theoretical views would lead them to reject it; as, for example, Mr Bentham himself. He supposes a controversy between an ancient and a modern moralist. (*Deont.*, vol. i., p. 72.) "The modern, as probably he will keep neither his principles nor his temper, says to the ancient, 'Your moral sense is nothing to the purpose; yours is corrupt, abominable, detestable; all nations cry out against you.' 'No such thing,' replies the ancient; 'and if they did, it would be nothing to the purpose: our business was to inquire, not what people *think*, but what they *ought to think*.'" And this "ought" of the ancients is supposed to terminate the controversy, so far as dialogue is concerned.[2]

(5.) It is, indeed, expressly allowed by Mr Bentham himself, that the word *utility*, and its conjugates, do not express our judgment in cases of moral conduct. "The mind will not be satisfied," he says (vol. i., p. 35), "with such phrases as—'it is useless to commit murder,' or 'it would be useful to prevent it.'" Surely we may be allowed to say that the reason why men are not *satisfied* with such phrases is, that they do not express their meaning. The repugnance and indignation with which we regard crimes and vices is something distinct from the perception of their results; and no word which expresses the transgression of utility satisfies us, except it also express the transgression of rectitude. Murder is harmful to society, but it is also wicked. The former expression states the view of our understanding as to the consequences of the act; the latter expression conveys the feeling of our moral nature as to its moral quality: the utilitarian scheme of Mr Bentham appears to aim at confounding these assertions.

(6.) But the same recognition of the difference of duty and usefulness in common apprehension, which Mr Bentham has made in the passage just quoted, appears also in other circumstances; as, for instance, in the title of the work already quoted, *Deontology*, and in the reasons assigned for coining such a name. This term is professedly chosen because "utilitarianism offers too vague and undefined an impression to the mind." (Vol. i., p. 34.) If the word from which Deontology is derived had borrowed its meaning from the notion of utility alone, it is not likely that it would have become more intelligible by being translated out of Latin into Greek. But the term Deontology expresses Moral Science (and expresses it well), precisely because it signifies the *Science of Duty*, and contains no reference to utility. It is a term well chosen, to describe a system of ethics founded on any other than Mr Bentham's principle. Mackintosh, who held that τὸ δέον,—what men *ought* to do,—was the fundamental notion of morality, might very properly have termed the science Deontology. The system of which Mr Bentham is the representative—that of those who make morality dependent on the production of happiness, has long been designated in Germany by the term *Eudemonism*, derived from the Greek word for happiness (ἐυδαιμονία). If we were to adopt this term we should have to oppose the Deontological to the Eudemonist school; and we must necessarily place those who hold a peculiar moral faculty,—Butler, Stewart, Brown, Mackintosh,—in the former, and those who are usually called utilitarian philosophers in the latter class.

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[1] The title of this book is "Deontology, &c., from the MSS. of Jeremy Bentham;" but recently I have been blamed in a Review for citing it as his. (1852.)

[2] Perhaps the reader may be amused by Mr Bentham's mode of winding up the scene:—"Thereupon the modern kicks the ancient, or spits in his face; or, if he is strong enough, throws him behind the fire. One can think of no other method that is at once natural and consistent, of continuing the debate." It is satisfactory to see that Mr Bentham does not seem to have thought the use of the word *ought* by the one party, though very provoking, justified the extreme measures which he describes on the other side.

(7.) The irrelevancy of Paley's mode of treating the question of the moral sense is so generally allowed at present that we need not dwell on it here. But we may observe, that other mistakes, flowing from a like misapprehension, effect his analysis of virtue. He endeavours to make an advance in this inquiry by the question, "Why am I obliged to keep my word, or to do any other moral act?" And by his answer to this question, he reduces moral obligation to two elements—external constraint, and the command of a superior. This attempt at an analysis of morality is singularly futile: for, of the two supposed elements, external constraint annihilates the morality of the act, and the reference to a superior presupposes moral obligation, since a superior is one whom it is our duty to obey. If Paley had stated his question in the simpler form, "Why *ought* I to keep my word?" he would have had before him a problem more to the purpose of moral philosophy, and one to which his answer would have been palpably inapplicable.

(8.) The argument hitherto urged has been, that the impossibility of resolving the ideas of moral right and duty into other ideas, borrowed from utility, is implied in the common use of language; and virtually acknowledged by utilitarian writers themselves. Other arguments may be drawn from the nature of the feelings with which we contemplate actions, and which, it has been truly said, are quite irreconcileable with the supposition that our moral estimate of actions arises from their bearing on happiness, and that our moral estimate of men looks only to their having calculated such consequences well or ill. Our admiration of the higher virtues, our indignation and scorn of the baser vices, are entirely different from an assent to, or dissent from, the agent's estimate of consequences. We can conceive a remorse for sins committed, which is something very distinct from a regret at having mistaken the road to happiness. A bad man, in a moral sense, is not merely a man who has had a bad head for calculating consequences, as he would be if morality resided in the intellect alone. But this argument has been sufficiently insisted upon by others.

(9.) Thus, as we separate the affections from the desires, we distinguish the moral sense, or conscience, from both. Butler, and Mackintosh with him, express the relation of conscience to the other principles of action, by ascribing to it a *supremacy*,[1] or a right of command. This language is metaphorical, but in that respect it does not differ from all the rest of the language which we use concerning mental operations and relations; and the material question is, whether, in this case, the language is intelligible. It is language which has been familiarly used from the time of Aristotle and Plato to our own; and I think it will be seen by any one who reads with attention the pages of good writers who employ this language, as for instance Butler, that they have a distinct meaning in their minds, and that their expressions are fitted to convey it. Butler shews that prudential self-love is a principle differing from the desires and passions in other ways than in mere strength; and thus establishes that there is a difference of kind and order, as well as of degree and power, among our active principles. He reminds us that we can conform our acts to rules, and that this differs from acting as we please, or obeying the strongest impulse; that man is intelligibly said to contain in his own mind a law of right action; that under the influence of such a principle he approves and condemns, and thus passes judgment on acts and dispositions; that this is the proper office of such a principle;

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[1] The use of the term *Supremacy*, as ascribed to the conscience, is liable to convey an erroneous and dangerous doctrine, that every one's conscience is for him the supreme rule of right and wrong. The word *Authority*, which is all that Butler and Mackintosh's argument requires, avoids this inconvenience.

See the Preface to Whewell's edition of Butler's Three Sermons on Human Nature, and Whewell's Elements of Morality, art. 271, 2d edit. (Note added 1852.)

and that right and authority are implied in this office. When we have distinguished the moral sense from the other faculties of our nature, such language appears to convey, as well as language can convey, the relation of that faculty to the others. "To declare what ought and ought not to be done," it has been said, "is the essence of command, that is, of moral command or rightful authority." And thus such authority belongs to the faculty which determines that some of our actions and emotions are, and others are not, what they ought to be.

We shall have to speak farther of this supremacy of conscience in treating of Mackintosh's explanation of it. But we may, in the first place, say a few words on the application of this doctrine to questions of ethics.

(10.) Mackintosh has, with great propriety, insisted upon the importance of a distinction of two parts of Moral Philosophy, which are often confounded;—the Theory of Moral Sentiments, and the Criterion of Morality, (p. 313.) The question of the independent existence and character of the moral faculty belongs to the former division of the subject; the construction of our system of ethics flows from the latter. There is no necessary collision between doctrines on these two points. We may hold that morality is an original quality of actions, and may still form our rules of morality by tracing the consequences of actions.

This distinction has often been neglected. Those who hold that utility constitutes morality, often call upon the advocates of a moral sense, to shew how the assertion of such a faculty leads us to distinguish right from wrong, or how it can supersede the criterion of general utility. To this it may be replied;—that the existence of a moral conscience in man is an important truth, but that this truth alone cannot be expected to replace all the principles and deductions by which a sound system of philosophical ethics is to be produced; that the construction of such a system is undoubtedly a difficult problem;—but that we shall inevitably obtain an erroneous solution of the problem, if we do not take into our account the operation of the moral faculty. The criterion of utility cannot safely be applied without acknowledging the independent value of morality, any more than the moral faculty can always decide well without the consideration of consequences. For among the most important results of actions, we must include their effect upon the moral habits and feelings of men; and must consider these effects as claiming attention for their own sake. The promotion of human virtue must be our aim, as well as the augmentation of human happiness. We cannot by any analysis exclude the former of these ends; happiness depends on the exercise of the virtuous affections, far more clearly than virtue depends on the pursuit of happiness. The most wise and moderate of the utilitarian moralists do, accordingly, apply their method in this manner. Thus Paley, (B. III., p. III., C. III.) in estimating the guilt of corrupting a person to the commission of one offence, states it as one ground of condemnation, that such seduction is the destruction of the person's moral principle. And it appears, at present, to be generally allowed, that the utilitarian doctrine cannot be applied without considering the effect on the moral feelings of men as among the important consequences of action. "It often happens," it is said, "that an essential part of the morality or immorality of an action, or a rule of action, consists in its influence on the agent's own mind." "Many actions moreover, produce effects on the characters of other persons besides the agent." The effects here spoken of are, in fact, effects on the moral habits of thought; and thus the existence of the moral attributes of the mind, as original and independent objects of the attention of the ethical philosopher, is presupposed in this mode of applying the utilitarian scheme.

If, indeed, we take *such* good and bad consequences into the account;—if among the useful effects of actions, we conceive the most useful to be the improvement of man's moral character;—if we frame our rules so that they shall conduce as much as possible to virtuous feeling, as well as to beneficial action,—to purity of heart, as well as to rectitude of conduct;—if we aim at man's general well-being, and not merely at his gratification;—I know not what moralist would object to a criterion of morality so drawn from consequences, or would deny that the promotion of human happiness, and of human virtue, require the same practical rules. Mackintosh would undoubtedly have assented to this; for he not only allows the universal coincidence of virtue with utility in the largest sense (p. 417), but founds his recommendation of the highest forms of virtue on the advantage of virtuous habits and feelings, both to the possessor and to the community; as when he speaks of the trite example of Regulus (p. 355), of the character of Andrew Fletcher (p. 399), and of the virtue of courage (p. 397). If we could take into due account the whole value of right principles, and the whole happiness produced by virtuous feelings, we could commit no practical error in making the advantageous consequences of actions the measure of their morality.

But this can happen only by considering moral good as a primary object, valuable for its own sake; not by supposing that virtue is aimed at, as subservient to some other purpose of more genuine utility: and no sagacity or fairness in estimating useful consequences can stand as a substitute for the love of right itself. It is true, that honesty is the best policy; but he who is honest only out of policy, does not come up even to the vulgar notion of a virtuous man. If a man were tempted by the opportunity of gaining a large estate through a safe but fraudulent proceeding, the utilitarian doctrine would seem to recommend him to weigh both sides well, though it would direct him in conclusion to decide in favour of probity; but the common judgment of mankind would hardly deem him honest if he hesitated at all. And in like manner in regard to other temptations, the safety of virtue appears to consist so little in tracing all possible consequences, that it has been held, that to deliberate is to be lost, and that the only secure protection is that purity of mind which will not look at the prospect of sensual pleasure when it forms one side of the account. We cannot help saying with Cicero, "Hæc nonne est turpe dubitare philosophos, quæ ne rustici quidem dubitent?" (*Off.* III. 19.)

Indeed, it appears to be acknowledged by the advocates of the rule of utility, that it is not safe to apply the principle separately in each particular case. Mr Bentham has urged with great beauty of expression (*Deontology*, vol. ii., ch. i.), the propriety of framing general rules, and conforming our practice invariably to these, so as to avoid the temptations of our frailty and passion in particular instances. If a reverence for general maxims of morality, and a constant reference to the common precepts of virtue, take the place, in the utilitarian's mind, of the direct application of his principle, there will remain little difference between him and the believer in original moral distinctions; for the practical rules of the two will rarely differ, and in both systems the rules will be the moral guides of thought and conduct.

(11.) But though the two schools agree so far, there still will be found a deficiency on the part of the consistent utilitarian. A persuasion that moral good is something different from, and superior to, mere pleasure, is requisite to give our preference of it that tone of enthusiasm and affection which belongs to virtuous feeling. To approve a rule as right, is different from liking it as profitable; to admire an act of virtuous self-devotion as we are capable of admiring, is a feeling so different from the apprehension of any usefulness the act may have, that the comparison of the two things is altogether incongruous. The moral faculty converts our perception of the quality of actions into an affection of the strongest kind; nor can we be satisfied with any account of our moral sentiments which excludes this feature in the process. Thus, as we hold the affections to be motives of an order superior to the desires which have reference to ourselves only, we maintain the moral faculty, the conscience, the affection towards duty, to be a principle of action of an order superior both to the desires and to the other affections. Without the acknowledgement of this subordination, the language and feelings of men when they compare the claims of personal pleasure, of social affection, and of duty, are altogether unintelligible and absurd.

(12.) Of those who have held the doctrine opposite of this, namely, that all these sentiments are composed of elements the same in kind, Paley has expressed the opinion in perhaps the most offensive form, being carried on partly by his love of clearness, and partly by his indifference to mere speculation. "In this inquiry," he says, "I will omit much declamation on the dignity and capacity of our nature, the superiority of the soul to the body, the rational to the animal part of our constitution: upon the worthiness, refinement, and delicacy of some satisfactions, and the meanness, grossness, and sensuality of others; because *I hold that pleasures differ in nothing but in continuance and in intensity*."

If we could use such a term without an unbecoming disrespect towards a virtuous and useful writer, this opinion might properly be called brutish, since it recognises no difference between the pleasures of man and those of the lowest animals. If we are to promote human happiness in this sense, I do not see how the same obligation does not lie upon us to promote the happiness of brutes with the same care. And if the pleasures of sense differ only in intensity and duration from the pleasures of filial and parental affection, we ought to know how many days of luxurious living are equivalent to the pleasure of saving a father's life, that we may decide rightly when these claims happen to come in competition. If utilitarian moral obligation consists in being regulated by such calculations, we cannot be surprised at the disgust with which so many persons speak of the scheme which refers us to "the calculations of utility."

(13.) I shall not pretend to determine whether Mr Bentham, and those who agree with him, have sometimes overlooked the conditions under which alone their principle can be safely applied; or whether, at any period, they were justly liable to Mackintosh's censure (p. 392) of "clinging to opinions because they are obnoxious; of wantonly wounding the most respectable feelings of mankind." In more recent times this cannot, I think, be said of them; for extreme opinions on the political questions of the day, however unfavourable may be their influence on the moral speculations with which they are combined, are not appropriately spoken of in such terms. At present I think we may discern in utilitarian writers a wish to conciliate rather than to shock the moral sympathies of their countrymen; and perhaps the opposite schools of moralists may thus be brought nearer to each other. If those who profess to make the utility of our actions the measure of their morality, include in utility the effect upon the moral habits of ourselves and others;—if they repel with indignation the charge that they lose sight of virtuous feeling, and of the beneficial influence of good actions on the frame of mind;—if they claim to have their estimate of good interpreted in the same way as Plato's; and speak of "that generous and inspiring tone which gives so much of their usefulness as well as of their charm" to writings such as his;—if they even become discontented with the name of utility, and wish to have their science called deontology;—the question at issue between them and their opponents ceases to be a difference of moral rule, and, almost, to be a discordance of moral feeling; and becomes rather a point of metaphysical analysis. They do not indeed become a deontological school, but they shew how near a eudemonist school may approach to being so.

Whether such an approximation would gratify the writers to whom I refer, I have no means of knowing; and if I am told that I am mistaken in my interpretation of the indications to which I have alluded, I shall not attempt to maintain the opinion. It would be nothing new or strange if persons honestly seeking truth from different quarters, should be led towards the same point; but if they bring with them an angry and hostile spirit, they may approach only to quarrel more bitterly. It is, however, possible to seek truth of all kinds in a calm and charitable temper; and it would be very strange if moral truths were held to be an exception to the desirableness of doing this. Captiousness and petulance, fierceness and menace, personal contumely and angry buffoonery, may be used in this as in other discussions; but I conceive that no writer on morals, duly feeling the dignity and obligations of his office, will, by any act of his, recognise those who have recourse to such modes of treating the subject, as moral philosophers.[1]

III. I now proceed to notice a third principle which enters into Mackintosh's philosophy, and which, in the way in which he holds it, is more peculiar to him than the two hitherto stated. He assents, in a great measure, to the explanation suggested by Hume and Smith (p. 376), but more fully developed by Hartley (p. 382), of the formation of our passions and affections, and even of our sentiments of virtue and duty, by means of "the association of ideas." He further urges this theory more at length in his general remarks (p. 421).

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[1] Perhaps we have now reached a period, when I may remark, without reviving any angry feelings, that these expressions were intended to refer to Criticisms of this Dissertation of Mackintosh which had been published, and especially to a *Fragment on Mackintosh*, the title of which was, I suppose, suggested by Bentham's *Fragment on Government*, the latter being a severe criticism on a portion of Blackstone's *Commentaries*. (Note added 1852.)

(1.) But into this view, as usually understood, he introduces several modifications; and, in particular, he asserts that the effect of such "association" may be something very different from the mere juxtaposition of the component elements. Thus he says that the result may be so entirely a single sentiment, that "the originally separate feelings can no longer be disjoined" (p. 384); and, moreover, that "the compound may have properties not to be found in any of its component parts;" as constantly happens, he observes, in material compounds.

It is clear that this view of the effect of the "association of ideas," may give results very different from those often founded upon that doctrine. If we say that gratitude, or compassion, or patriotism, are *only* certain trains of pleasurable associations, we are generally understood to assert that we can again resolve those feelings into the constituent and associated elements; and that by so doing we may hope to reason upon them most philosophically and exactly. But Mackintosh's mode of considering these and other emotions would allow of neither of these inferences. He supposes "association" to be employed in the education rather than in the creation of our moral sentiments; in awakening affections rather than in connecting notions.

(2.) The ideas or the feelings which are concerned in this process, are said to be *associated;* but this is, he declares, a very inadequate word to express the "complete combination and fusion" which occur (p. 381). This association presupposes laws and powers of the mind itself, according to which the conjunction produces its results. The celebrated comparison of the mind to a sheet of white paper is not just, except we consider that there may be in the paper itself many circumstances which affect the nature of the writing (p. 380). A recent writer, however, appears to me to have supplied us with a much more apt and beautiful comparison. Man's soul at first, says Professor Sedgwick, is one unvaried blank, till it has received the impressions of external experience. "Yet has this blank," he adds, "been already touched by a celestial hand; and, when plunged in the colours which surround it, it takes not its tinge from accident but design, and comes out covered with a glorious pattern." —(*Discourse on the Studies of the University*, p. 54.) This modern image of the mind as a prepared blank, is well adapted to occupy a permanent place in opposition to the ancient sheet of white paper.

(3.) Not only the word association, but also the word *ideas*, in the Lockian expression, appears to Mackintosh to be unsuited to its purpose: since an association takes place "of thoughts with emotions, as well as with each other" (p. 382). Our author has indeed shewn great solicitude to bring into clear view that part of our nature which he here distinguishes from thought;—"that other part of it, hitherto without any adequate name, which feels, and desires, and loves, and hopes, and wills" (p. 336). After balancing the various terms which may be used to express the aggregate of such feelings, he inclines finally to call it the *emotive* or *pathematic*[1] part of man (p. 380).

Thus the "association of ideas," according to Mackintosh, would more properly be termed the composition of ideas and emotions. In his view of the composite, as losing all trace of apparent composition, the author was, in some measure, following Hartley (p. 385), though he justly claims the credit (p. 384) of seeing more distinctly than his predecessors the important truth, that the compound may have properties not found in any of its component parts.

(4.) Mackintosh maintains that this is by no means a modification of the selfish system (p. 407); for the "affections and the moral sentiments, though educed by association, only become what they are when they lose all trace of self-regard." "If the affections be *acquired*, they are justly called *natural;* and if their origin be personal, their nature may and does become *disinterested.*"

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[1] These terms have not had much "luck" (to use Mackintosh's own phraseology in this passage). In common language, this part of our nature is often called *the heart*, as distinguished from *the head*. We may perhaps best describe it by the compound phrase used in the Dissertation itself; *the desires and affections*. Some recent writers have spoken of the *emotional* part of our nature. (1852.)

IV. But we must now consider another peculiarity of Mackintosh's system; I speak of what he names his *Theory of Conscience.*

(1.) Being persuaded, as we have seen, that the moral faculty exists and exercises a rightful supremacy over the active principles, he has attempted to explain and account for this relation of our emotions. His view is given in his remarks on Butler (p. 362), and again in his concluding remarks (p. 425). According to this theory, the moral faculty consists of a class of desires and affections which have dispositions and volitions for their sole object. This description of our moral sentiments will, he conceives, explain their peculiar character and attributes. He expresses the relation which he wishes to describe, by saying that the moral sentiments are *in contact with the will* (p. 362); or, as he further elucidates this, "they may and do stand between any other practical principle and its object, while it is absolutely impossible that any other shall intercept their connection with the will." The conscience requires virtuous acts and dispositions to action; and by such requisition it can check and control any desires of external objects; but no desire of any outward gratification can prevent the conscience from demanding a virtuous direction of the will; and this mental relation explains and justifies, Mackintosh conceives, that attribution of supremacy and command to the conscience on which moral writers have often insisted (p. 362).

(2.) Thus conscience consists in, or rather results from, the composition of *all* those sentiments, of which the final object is a state of the will, intimately and inseparably blended, and held in a perfect state of solution (p. 424); and the conscience being thus represented as analogous to the desires, it implies, in the same way as other desires, a *sense* of what is grateful, and a faculty of dwelling, in thought, on the gratification so obtained.

(3.) But if, in order further to develop this theory, it be asked *what* states of the will are thus agreeable to the conscience; or, in other words, what, according to this system, is the general character of the dispositions and actions which we consider good and right; Mackintosh's answer would be, that the conscience, being educated and awakened by certain processes of association, is thus composed of various elements, and finds good under various forms;—that (p. 423) the beneficial volitions are delightful, and that, therefore, they strongly attract those affections which regard the will, and thus give rise to some of the elements of conscience;—that our anger against those who disappoint our wish for the happiness of others, when in like manner detached from persons and transferred to dispositions, becomes a sense of justice, another element of conscience;—that courage, energy, decision, when tamed by the society of the affections, and considered as dispositions only, become magnanimity, and gratify the moral sense;—and that even those habits which mainly affect our own good, as temperance, prudence, when they become disposition and not calculation, are for like reasons, added to the constituents of conscience (p. 424).

(4.) Thus the view of the nature of conscience here presented, explains how it is that the private desires and the social affections alike fall under the authority of the moral faculty. The explanation of this community of rule in sentiments of so widely different nature, Mackintosh considers a strong confirmation of the justice of his opinion (p. 425).

Without pronouncing a judgment on the truth of this theory, I hope I have faithfully represented the author's meaning. But he draws from the theory certain inferences, of which I may say a few words.

V. Mackintosh, as we have seen, maintains that though the moral faculty is formed or educed by intercourse with the external world, it is a law of our nature; yet he allows that what this law prescribes, agrees with the rule, rightly understood, of bringing forth the greatest happiness. He was, therefore, naturally called upon to account for this coincidence. If moral approval be a different sentiment from the estimation of general happiness, why does the moral sense of man invariably approve that which increases the happiness of his species? If this theory account for this phenomenon, such a circumstance will, he conceives, be a strong argument in its favour.

(1.) He replies to this inquiry (p. 426), that all the separate objects which conscience approves, the social affections, the decisions of justice, the maxims of enlightened prudence, tend to the happiness of some part of the species, and and that thus the general rules of conscience must agree with the rules of the general happiness. All the acts which the moral faculty sanctions promote the welfare of some part of mankind, and all that reason has to do is to add up the items of the account. All the principles of which conscience is composed, converge towards the happiness of man; and therefore this may be taken as its central point. And thus the coincidence just noticed is not accidental, but is a necessary consequence of the theory.

(2.) I will add, as a corollary to what Mackintosh has said, that a system of ethics, rightly constructed on the principle of promoting, in the greatest degree, the happiness of mankind, will coincide, in most of its rules of action, with a system founded on the supreme authority of conscience; but that, in order to apply safely and well the eudemonist principle, we must recollect that happiness consists rather in habits of the mind than in outward gratifications; and is to be sought rather by forming moral dispositions than by prescribing acts. In Paley's "Moral Philosophy," we have a work framed on the eudemonist basis, which has for some time possessed considerable authority in this country, and has probably in no small degree influenced men's reasonings on such subjects in recent times. Without examining here how far Paley has always applied his principle under due conditions, and traced his consequences with a sufficiently enlarged survey, we may observe that there prevails through the work a tone of practical sagacity, good sense, and good feeling, which neutralizes most of its theoretical defects.

VI. Some other bearings of Mackintosh's theory may be noticed, and especially the view it offers of the relation of religion and morality. This agrees nearly with the doctrine of Butler, and many English divines, that conscience is one of the ways in which the commands of God are conveyed to us (p. 427). "The completeness and rigour acquired by conscience when all its dictates are revered as the commands of a perfectly good and wise Being, are so obvious, that they cannot be questioned by any reasonable man, however wide his incredulity may be. It is thus that conscience can add the warmth of an affection to the inflexibility of principle and habit." Not only are we bound to accept all the precepts for the moral government of the will, disclosed either by Revelation or by reason, as undeniable rules for our feelings and actions; but the relations between man and his Maker, which religion teaches us, tend to make this a work of love, no less than of duty; and bestow on that improvement of our inward nature to which conscience is constantly urging us, an aspect of hope and joy, which human morality, without such aid, can hardly assume, and seldom long retain.

VII. I will only refer to one other consequence of this theory of conscience of Mackintosh;—the view it appears to him to supply of the celebrated question of Free-will (p. 430). Since conscience contemplates those dispositions only which depend on the will, it excludes all consideration of the cause in which the will originated: hence the voluntary dispositions appear as the first link of the chain; and, in the eye of conscience, will is the independent cause of action. Reason, on the other hand, must consider occurrences as bound together by the connection of cause and effect, and thus sees only the strength of the necessitarian system. Thus, while speculation appears to shew that our actions are necessary, practice convinces us that they are free. The advocates of necessity and of free-will look at the question from different points of view;—that of the understanding and that of the conscience. But the conscientious view being strengthened by the moral sympathy of mankind, is by far the most generally and strongly entertained.

I shall here close my remarks on the Dissertation which the following pages contain. The theoretical view of the nature, formation, and operation of our moral sentiments, which is given by the author, must be left to the consideration of those who pursue such speculations in a philosophical spirit and temper. His historical sketch of the progress of the subject has in it much to please and instruct, to interest and improve the ethical student. There will be found several instances in which the phraseology is defective in clearness and simplicity; and in this, as in any work, if we pay no attention to the writer's aim, if we insist upon confounding what he has distinguished, and upon interpreting his language by an analysis which he did not acknowledge, we shall not obtain his sense, or any sense. But the reader who candidly seeks for the author's meaning will, I think, not fail to find it: and I am persuaded that most readers will derive pleasure from the comprehensive views, the tolerant temper, and the love of virtuous feeling and literary beauty which they will find pervading the work. His unfavourable judgments, in those cases in which he expresses such, are less severe than those of other philosophers, both in our own and in other countries, who look at the progress of moral philosophy from a like point of view; and he always appears to rejoice to give credit to any writers in whom he discovers the early gleams of those doctrines which he held to be important truths.

In the conclusion of his survey, he speaks of the spirit of speculation on this subject, as all but extinct in this country. I would willingly believe that this is too desponding a view of the fortunes of moral philosophy among us;—that the youth of England are far from indifferent to the questions which concern the nature and laws of man's highest faculties, and which excite a vigorous and generous love of speculation in other parts of Europe. To such a result I look forward the more gladly, because I do not doubt that the reigning philosophy of any age, even when it excites little direct attention, influences powerfully men's convictions and habits of thought; and I am persuaded that we cannot make the prevalent views of morals sounder, purer, and more philosophical, without improving the general intellectual and moral character of the educated classes of the nation.

W. W.

DISSERTATION SECOND.

INTRODUCTION.

The inadequacy of the words of ordinary language for the purposes of Philosophy, is an ancient and frequent complaint; of which the justness will be felt by all who consider the state to which some of the most important arts would be reduced, if the coarse tools of the common labourer were the only instruments to be employed in the most delicate operations of manual expertness. The watchmaker, the optician, and the surgeon, are provided with instruments which are fitted, by careful ingenuity, to second their skill; the philosopher alone is doomed to use the rudest tools for the most refined purposes. He must reason in words of which the looseness and vagueness are suitable, and even agreeable, in the usual intercourse of life, but which are almost as remote from the extreme exactness and precision required, not only in the conveyance, but in the search of truth, as the hammer and the axe would be unfit for the finest exertions of skilful handiwork; for it is not to be forgotten, that he must himself think in these gross words as unavoidably as he uses them in speaking to others. He is in this respect in a worse condition than an astronomer who looked at the heavens only with the naked eye, whose limited and partial observation, however it might lead to error, might not directly, and would not necessarily deceive. He might be more justly compared to an arithmetician compelled to employ numerals not only cumbrous, but used so irregularly to denote different quantities, that they not only often deceived others, but himself.

The Natural Philosopher and Mathematician have in some degree the privilege of framing their own terms of art; though that liberty is daily narrowed by the happy diffusion of these great branches of knowledge, which daily mixes their language with the general vocabulary of educated men. The cultivator of Mental and Moral Philosophy can seldom do more than mend the faults of his words by definition; a necessary but very inadequate expedient, in a great measure defeated in practice by the unavoidably more frequent recurrence of the terms in their vague than in their definite acceptation; in consequence of which the mind, to which the definition is faintly and but occasionally present, naturally suffers, in the ordinary state of attention, the scientific meaning to disappear from remembrance, and insensibly ascribes to the word a great part, if not the whole, of that popular sense which is so very much more familiar even to the most veteran speculator. The obstacles which stood in the way of Lucretius and Cicero, when they began to translate the subtile philosophy of Greece into their narrow and barren tongue, are always felt by the philosopher when he struggles to express, with the necessary discrimination, his abstruse reasonings in words which, though those of his own language, he must take from the mouths of those to whom his distinctions would be without meaning.

The Moral Philosopher is in this respect subject to peculiar difficulties. His statements and reasonings often call for nicer discriminations of language than those which are necessary in describing or discussing the purely intellectual part of human nature; but his freedom in the choice of words is more circumscribed. As he treats of matters on which all men are disposed to form a judgment, he can as rarely hazard glaring innovations in diction, at least in an adult and mature language like ours, as the orator or the poet. If he deviates from common use, he must atone for his deviation by hiding it, and can only give a new sense to an old word by so skilful a position of it as to render the new meaning so quickly understood that its novelty is scarcely perceived. Add to this, that in those most difficult inquiries for which the utmost coolness is not more than sufficient, he is often forced to use terms commonly connected with warm feeling, with high praise, with severe reproach; which excite the passions of his readers when he most needs their calm attention and the undisturbed exercise of their impartial judgment. There is scarcely a neutral term left in Ethics; so quickly are such expressions enlisted on the side of Praise or Blame, by the address of contending passions. A true philosopher must not even desire that men should less love virtue or hate vice, in order to fit them for a more unprejudiced judgment on his speculations.

There are perhaps not many occasions where the penury and laxity of language are more felt than in entering on the history of sciences where the first measure must be to mark out the boundary of the whole subject with some distinctness. But no exactness in these important operations can be approached without a new division of human knowledge, adapted to the present stage of its progress, and a reformation of all those barbarous, pedantic, unmeaning, and (what is worse) wrong-meaning names which continue to be applied to the greater part of its branches. Instances are needless where nearly all the appellations are faulty. The term *Metaphysics* affords a specimen of all the faults which the name of a science can combine. To those who know only their own language, it must, at their entrance on the study, convey no meaning. It points their attention to nothing. If they examine the language in which its parts are significant, they will be misled into the pernicious error of believing that it seeks something more than the interpretation of nature. It is only by examining the history of ancient Philosophy that the probable origin of this name will be found, in the application of it, as the running title of several essays of Aristotle, which were placed in a collection of the manuscripts of that great philosopher, after his treatise on *Physics*. It has the greater fault of an unsteady and fluctuating signification; denoting one class of objects in the seventeenth century, and another in the eighteenth—even in the nineteenth not quite of the same import in the mouth of a German, as in that of a French or English philosopher; to say nothing of the farther objection that it continues to be a badge of undue pretension among some of the followers of the science, while it has become a name of reproach and derision among those who altogether decry it.

The modern name of the very modern science called *Political Economy*, though deliberately bestowed on it by its most eminent teachers, is perhaps a still more notable sample of the like faults. It might lead the ignorant to confine it to retrenchment in national expenditure; and a consideration of its etymology alone would lead into the more mischievous error of believing it to teach, that national wealth is best promoted by the contrivance and interference of lawgivers, in opposition to its surest doctrine, which it most justly boasts of having discovered and enforced.

It is easy to conceive an exhaustive analysis of Human Knowledge, and a consequent division of it into parts corresponding to all the classes of objects to which it relates:—a representation of that vast edifice, containing a picture of what is finished, a sketch of what is building, and even a conjectural outline of what, though required by completeness and convenience, as well as symmetry, is yet altogether untouched. A system of names might also be imagined derived from a few roots, indicating the objects of each part, and showing the relation of the parts to each other. An order and a language somewhat resembling those by which the objects of the sciences of Botany and Chemistry have, in the eighteenth century, been arranged and denoted, are doubtless capable of application to the sciences generally, when considered as parts of the system of knowledge. The attempts, however, which have hitherto been made to accomplish the analytical division of knowledge which must necessarily precede a new nomenclature of the sciences, have required so prodigious a superiority of genius in the single instance of approach to success by Bacon, as to discourage rivalship nearly as much as the frequent examples of failure in subsequent times. The nomenclature itself is attended with great difficulties, not indeed in its conception, but in its adoption and usefulness. In the Continental languages to the south of the Rhine, the practice of deriving the names of science from Greek must be continued; which would render the new names for a while unintelligible to the majority of men. Even in Germany, where a flexible and fertile language affords unbounded liberty of derivation and composition from native roots or elements, and where the newly derived and compounded words would thus be as clear to the mind, and almost as little startling to the ear of every man, as the oldest terms in the language, yet the whole nomenclature would be unintelligible to other nations. The intercommunity of the technical terms of science in Europe has been so far broken down by the Germans, and the influence of their literature and philosophy is so rapidly increasing in the greater part of the Continent, that though a revolution in scientific nomenclature be probably yet far distant, the foundation of it may be considered as already prepared.

But although so great an undertaking must be reserved for a second Bacon and a future generation, it is necessary for the historian of any branch of knowledge to introduce his work by some account of the limits and contents of the sciences of which he is about to trace the progress; and though it will be found impossible to trace throughout the treatise a distinct line of demarcation, yet a general and imperfect sketch of the boundaries of the whole, and of the parts of our present subject, may be a considerable help to the reader, as it has been a useful guide to the writer.

There is no distribution of the parts of knowledge more ancient than that of the *Physical* and *Moral* Sciences, which seems liable to no other objection, than that it does not exhaust the subject. Even this division, however, cannot be safely employed, without warning the reader, that no science is entirely insulated, and that the principles of one are often only the conclusions and results of another. Every branch of knowledge has its root in the theory of the Understanding, from which even the mathematician must learn what can be known of his magnitude and his numbers; and Moral Science is founded on that other hitherto unnamed part of the philosophy of human nature (to be constantly and vigilantly distinguished from *Intellectual* Philosophy), which contemplates the laws of sensibility, of emotion, of desire and aversion, of pleasure and pain, of happiness and misery; and on which arise the august and sacred landmarks that stand conspicuous along the frontier between Right and Wrong.

But however multiplied the connections of the Moral and Physical Sciences are, it is not difficult to draw a general distinction between them. The purpose of the Physical Sciences throughout all their provinces, is to answer the question *What is?* They consist only of facts arranged according to their likeness, and expressed by general names given to every class of similar facts. The purpose of the Moral Sciences is to answer the question *What ought to be?* They aim at ascertaining the rules which *ought* to govern voluntary action, and to which those habitual dispositions of mind which are the source of voluntary actions *ought* to be adapted.

It is obvious that *Will, Action, Habit, Disposition,* are terms denoting facts in human nature, and that an explanation of them must be sought in Mental Philosophy; which, if knowledge be divided into Physical and Moral, must be placed among physical sciences; though it essentially differs from them all in having for its chief object those laws of thought which alone render any other sort of knowledge possible. But it is equally certain that the word *Ought* introduces the mind into a new region, to which nothing physical corresponds. However philosophers may deal with this most important of words, it is instantly understood by all who do not attempt to define it. No civilized speech, perhaps no human language, is without correspondent terms. It would be as reasonable to deny that *Space* and *Greenness* are significant words, as to affirm that *Ought, Right, Duty, Virtue,* are sounds without meaning. It would be fatal to an Ethical Theory that it did not explain them, and that it did not comprehend all the conceptions and emotions which they call up. There never yet was a theory which did not attempt such an explanation.

SECTION I.

Preliminary Observations.

There is no man who, in a case where he was a calm by-stander, would not look with more satisfaction on acts of kindness than on acts of cruelty. No man, after the first excitement of his mind has subsided, ever whispered to himself with self-approbation and secret joy that he had been guilty of cruelty or baseness. Every criminal is strongly impelled to hide these qualities of his actions from himself, as he would do from others, by clothing his conduct in some disguise of duty or of necessity. There is no tribe so rude as to be without a faint perception of a difference between right and wrong. There is no subject on which men of all ages and nations coincide in so many points as in the general rules of conduct, and in the qualities of the human character which deserve esteem. Even the grossest deviations from the general consent will appear, on close examination, to be not so much corruptions of moral feeling, as either ignorance of facts; or errors with respect to the consequences of action; or cases in which the dissentient party is inconsistent with other parts of his own principles, which destroys the value of his dissent; or where each dissident is condemned by all the other dissidents, which immeasurably augments the majority against him. In the first three cases he may be convinced by argument, that his moral judgment should be changed on principles which he recognises as just; and he can seldom, if ever, be condemned at the same time by the body of mankind who agree in their moral systems, and by those who on some other points dissent from that general code, without being also convicted of error by inconsistency with himself. The tribes who expose new-born infants, condemn those who abandon their decrepit parents to destruction. Those who betray and murder strangers, are condemned by the rules of faith and humanity which they acknowledge in their intercourse with their countrymen. Mr Hume, in a dialogue in which he ingeniously magnifies the moral heresies of two nations so polished as the Athenians and the French, has very satisfactorily resolved his own difficulties. "In how many circumstances would an Athenian and a Frenchman of merit certainly resemble each other?—Humanity, fidelity, truth, justice, courage, temperance, constancy, dignity of mind......The principles upon which men reason in morals are always the same, though their conclusions are often very different."[1] He might have added, that almost every deviation which he imputes to each nation is at variance with some of the virtues justly esteemed by both; and that the reciprocal condemnation of each other's errors which appears in his statement entitles us on these points to strike out the suffrages of both, when collecting the general judgment of mankind. If we bear in mind that the question relates to the coincidence of all men in considering the same qualities as virtues, and not to the preference of one class of virtues by some, and of a different class by others, the exceptions from the agreement of mankind, in their system of practical morality, will be reduced to absolute insignificance; and we shall learn to view them as no more affecting the harmony of our moral faculties, than the resemblance of the limbs and features is affected by monstrous conformations, or by the unfortunate effects of accident and disease in a very few individuals.[2]

It is very remarkable, however, that though all men agree that there are acts which ought to be done, and acts which ought not to be done; though the far greater part of mankind agree in their list of virtues and duties, of vices and crimes; and though the whole race, as it advances in other improvements, is as evidently tending towards the moral system of the most civilized nations, as children in their growth tend to the opinions as much as to the experience and strength of adults; yet there are no questions in the circle of inquiry to which answers more various have been given than—How men have thus come to agree in the rule of life; Whence arises their general reverence for it; and What is meant by affirming that it ought to be inviolably observed? It is singular, that where we are most nearly agreed respecting rules, we should perhaps most differ as to the *causes* of our agreement, and as to the *reasons* which justify us for adhering to it. The discussion of these subjects composes what is usually called the *Theory of Morals*, in a sense not in all respects coincident with what is usually considered as Theory in other sciences. When we investigate the *causes* of our moral agreement, the term Theory retains its ordinary scientific sense; but when we endeavour to ascertain the *reasons* of it, we rather employ the term as importing the theory of the rules of an art. In the first case, Theory denotes, as usual, the most general laws to which certain facts can be reduced; whereas in the second, it points out the efficacy of the observance, in practice, of certain rules, for producing the effects intended to be produced in the art. These reasons also may be reduced under the general sense by stating the question relating to them thus:—What are the causes why the observance of certain rules enables us to execute certain purposes? An account of the various answers attempted to be made to these inquiries, properly forms the History of Ethics.

The attentive reader may already perceive, that these momentous inquiries relate to at least two perfectly distinct subjects: 1. The nature of the distinction between right and wrong in human conduct, and 2. The nature of those feelings with which right and wrong are contemplated by human beings. The latter constitutes what has been called the *Theory of Moral Sentiments;* the former consists in an investigation into the *Criterion of Morality* in action. Other most important questions arise in this province. But the two problems which have been just stated, and the essential distinction between them, must be clearly apprehended by all who are desirous of understanding the controversies which have prevailed on ethical subjects. The discrimination has seldom been made by Moral Philosophers; the difference between the two problems has never been uniformly observed by any of them: and it will appear, in the sequel, that they have been not rarely altogether confounded by very eminent men, to the destruction of all just conception and of all correct reasoning in this most important, and perhaps most difficult of sciences.

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[1] *Philosophical Works*, vol. IV. p. 420, 422. Edinb. 1826.

[2] " On convient le plus souvent de ces instincts de la conscience. La plus grande et la plus saine partie du genre humain leur rend témoignage. Les Orientaux, et les Grecs, et les Romains conviennent en cela; et il faudroit être aussi abruti que les sauvages Américains pour approuver leurs coutumes, pleines d'une cruauté qui passe même celle des bêtes. *Cependant ces mêmes sauvages sentent bien ce que c'est que la justice en d'autres occasions ;* et quoique il n'y ait point de mauvaise pratique peut-être qui ne soit autorisée quelque part, il y en a peu pourtant qui ne soient condamnées le plus souvent, et par la plus grande partie des hommes." (LEIBNITZ, *Œuvres Philosophiques*, p. 49. Amst. et Leipz. 1765, 4to.)

There are some admirable observations on this subject in Hartley, especially in the development of the 49th Proposition. " *The rule of life drawn from the practice and opinions of mankind corrects and improves itself perpetually, till at last it determines entirely for virtue, and excludes all kinds and degrees of vice.*" (*Observations on Man*, I. 207.)

It may therefore be allowable to deviate so far from historical order, as to illustrate the nature and to prove the importance of the distinction, by an example of the effects of neglecting it, taken from the recent works of justly celebrated writers; in which they discuss questions much agitated in the present age, and therefore probably now familiar to most readers of this Dissertation.

Dr Paley represents the principle of a moral sense as being opposed to that of utility.[1] Now, it is evident that this representation is founded on a confusion of the two questions which have been stated above. That we are endued with a moral sense, or, in other words, a faculty which immediately approves what is right and condemns what is wrong, is only a statement of the feelings with which we contemplate actions. But to affirm that right actions are those which conduce to the wellbeing of mankind, is a proposition concerning the outward effects by which right actions themselves may be recognised. As these affirmations relate to different subjects, they cannot be opposed to each other, any more than the solidity of earth is inconsistent with the fluidity of water; and a very little reflection will show it to be easily conceivable that they may be both true. Man may be so constituted as instantaneously to approve certain actions without any reference to their consequences; and yet reason may nevertheless discover, that a tendency to produce general happiness is the essential characteristic of such actions. Mr Bentham also contrasts the principle of utility with that of sympathy, of which he considers the moral sense as being one of the forms.[2] It is needless to repeat, that propositions which affirm or deny anything of different subjects, cannot contradict each other. As these celebrated persons have thus inferred or implied the non-existence of a moral sense, from their opinion that the morality of actions depends upon their usefulness, so other philosophers of equal name have concluded, that the utility of actions cannot be the criterion of their morality, because a perception of that utility appears to them to form a faint and inconsiderable part of our moral sentiments, if indeed it be at all discoverable in them.[3] These errors are the more remarkable, because the like confusion of perceptions with their objects, of emotions with their causes, or even the omission to mark the distinctions, would, in every other subject, be felt to be a most serious fault in philosophizing. If, for instance, an element were discovered to be common to all bodies which our taste perceives to be sweet, and to be found in no other bodies, it is apparent that this discovery, perhaps important in other respects, would neither affect our perception of sweetness, nor the pleasure which attends it. Both would continue to be what they have been since the existence of mankind. Every proposition concerning that element would relate to sweet bodies, and belong to the science of Chemistry; while every proposition respecting the perception or pleasure of sweetness would relate either to the body or mind of man, and accordingly belong either to the science of Physiology, or to that of Mental Philosophy. During the many ages which passed before the analysis of the sun's beams had proved them to be compounded of different colours, white objects were seen, and their whiteness was sometimes felt to be beautiful, in the very same manner as since that discovery. The qualities of light are the object of Optics; the nature of beauty can be ascertained only by each man's observation of his own mind; the changes in the living frame which succeed the refraction of light in the eye, and precede mental operation, will, if they are ever to be known by man, constitute a part of Physiology. But no proposition relating to one of these orders of phenomena can contradict or support a proposition concerning another order.

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[1] *Principles of Moral and Political Philosophy.* Compare book i. chap. v. with book ii. chap. vi.

[2] *Introduction to the Principles of Morality and Legislation*, chap. ii.

[3] SMITH's *Theory of Moral Sentiments*, Part iv. Even Hume, in the third book of his *Treatise of Human Nature*, the most precise, perhaps, of his philosophical writings, uses the following as the title of one of the sections: "MORAL DISTINCTIONS *derived from a Moral Sense.*"

The analogy of this latter case will justify another preliminary observation. In the case of the pleasure derived from beauty, the question whether that pleasure be original or derived is of secondary importance. It has been often observed that the same properties which are admired as beautiful in the horse, contribute also to his safety and speed; and they who infer that the admiration of beauty was originally founded on the convenience of fleetness and firmness, if they at the same time hold that the usefulness is gradually effaced, and that the admiration of a certain shape at length rises instantaneously without reference to any purpose, may, with perfect consistency, regard a sense of beauty as an independent and universal principle of human nature. The laws of such a feeling of beauty are discoverable only by self-observation. Those of the qualities which call it forth are ascertained by examination of the outward things which are called beautiful. But it is of the utmost importance to bear in mind, that he who contemplates the beautiful proportions of a horse, as the signs and proofs of security or quickness, and has in view these convenient qualities, is properly said to prefer the horse for his usefulness, not for his beauty; though he may choose him from the same outward appearance which pleases the admirer of the beautiful animal. He alone who derives immediate pleasure from the appearance itself, without reflection on any advantages which it may promise, is truly said to feel the beauty. The distinction, however, manifestly depends, not on the origin of the emotion, but on its object and nature when completely formed. Many of our most important perceptions through the eye are universally acknowledged to be acquired. But they are as general as the original perceptions of that organ; they arise as independently of our will, and human nature would be quite as imperfect without them. An adult who did not immediately see the different distances of objects from his eye, would be thought by every one to be as great a deviation from the ordinary state of man as if he were incapable of distinguishing the brightest sunshine from the darkest midnight. Acquired perceptions and sentiments may therefore be termed natural, as much as those which are more commonly so called, if they be as rarely found wanting. Ethical theories can never be satisfactorily discussed by those who do not constantly bear in mind, that the question concerning the existence of a moral faculty in man which immediately approves or disapproves without reference to any further object, is perfectly distinct, on the one hand, from that which inquires into the qualities thus approved or disapproved; and on the other, from an inquiry whether that faculty be derived from other parts of our mental frame, or be itself one of the ultimate constituent principles of human nature.

SECTION II.

Retrospect of Ancient Ethics.

Inquiries concerning the nature of mind, the first principles of knowledge, the origin and government of the world, appear to have been among the earliest objects which employed the understanding of civilized men. Fragments of such speculation are handed down from the legendary age of Greek philosophy. In the remaining monuments of that more ancient form of civilisation which sprung up in Asia, we see clearly that the Braminical philosophers, in times perhaps before the dawn of western history, had run round that dark and little circle of systems which an unquenchable thirst of knowledge has since urged both the speculators of ancient Greece and those of Christendom to retrace. The wall of adamant which bounds human inquiry has scarcely ever been discovered by any adventurer, until he was roused by the shock which drove him back. It is otherwise with the theory of morals. No controversy seems to have arisen regarding it in Greece, till the rise and conflict of the Stoical and Epicurean schools; and the ethical disputes of the modern world originated with the writings of Hobbes about the middle of the seventeenth century. Perhaps the longer abstinence from debate on this subject may have sprung from reverence for morality. Perhaps also, where the world were unanimous in their practical opinions, little need was felt of exact theory. The teachers of morals were content with partial or secondary principles, with the combination of principles not always reconcilable, even with vague but specious phrases which in any degree explained or seemed to explain the rules of the art of life—which seemed at once too evident to need investigation, and too venerable to be approached by controversy.

Perhaps the subtile genius of Greece was in part withheld from indulging itself in ethical controversy by the influence of Socrates, who was much more a teacher of virtue than even a searcher after truth—

> Whom, well inspired, the oracle pronounced
> Wisest of men.

It was doubtless because he chose that better part that he was thus spoken of by the man whose commendation is glory, and who, from the loftiest eminence of moral genius ever reached by a mortal, was perhaps alone worthy to place a new crown on the brow of the martyr of virtue.

Aristippus indeed, a wit and a worldling, borrowed nothing from the conversations of Socrates but a few maxims for husbanding the enjoyments of sense. Antisthenes also, a hearer but not a follower, founded a school of parade and exaggeration, which caused his master to disown him by the ingenious rebuke, "I see your vanity through your threadbare cloak."[1] The modest doubts of the most sober of moralists, and his indisposition to fruitless abstractions, were in process of time employed as the foundation of systematic scepticism; the most presumptuous, inapplicable, and inconsistent of all the results of human meditation. But though his lessons were thus distorted by the perverse ingenuity of some who heard him, the authority of his practical sense may be traced in the moral writings of those most celebrated philosophers who were directly or indirectly his disciples. Plato, the most famous of his scholars, the most eloquent of Grecian writers, and the earliest moral philosopher whose writings have come down to us, employed his genius in the composition of dialogues, in which his master performed the principal part. These beautiful conversations would have lost their charm of verisimilitude, of dramatic vivacity, of picturesque representation of character, if they had been subjected to the constraint of method. They necessarily presuppose much oral instruction. They frequently quote, and doubtless oftener allude to the opinions of predecessors and contemporaries whose works have perished, and of whose doctrines only some fragments are preserved.

In these circumstances, it must be difficult for the most learned and philosophical of his commentators to give a just representation of his doctrines, if he really framed or adopted a system. The moral part of his works is more accessible.[2] The vein of thought which runs through them is always visible. The object is to inspire the love of truth, of wisdom, of beauty, especially of goodness the highest beauty, and of that supreme and eternal mind, which contains all truth and wisdom, all beauty and goodness. By the love or delightful contemplation and pursuit of these transcendent aims for their own sake only, he represented the mind of man as raised from low and perishable objects, and prepared for those high destinies which are appointed for all those who are capable of them.

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[1] Diog. Laert. vi. Ælian. ix. 35.

[2] Heusde, *Initia Philosoph. Plat.* 1827; a hitherto incomplete work of great perspicuity and elegance, in which we must excuse the partiality which belongs to a labour of love.

The application to moral qualities of terms which denote outward beauty, though by him perhaps carried to excess, is an illustrative metaphor, as well warranted by the poverty of language as any other employed to signify the acts or attributes of mind.[1] The *beautiful* in his language denoted all that of which the mere contemplation is in itself delightful, without any admixture of organic pleasure, and without being regarded as the means of attaining any farther end. The feeling which belongs to it he called *love;* a word which, as comprehending complacency, benevolence, and affection, and reaching from the neighbourhood of the senses to the most sublime of human thoughts, is foreign from the colder and more exact language of our philosophy; but which perhaps then happily served to lure both the lovers of poetry and the votaries of superstition to the school of truth and goodness in the groves of the Academy. He enforced these lessons by an inexhaustible variety of just and beautiful illustrations,—sometimes striking from their familiarity, sometimes subduing by their grandeur; and his works are the storehouse from which moralists have from age to age borrowed the means of rendering moral instruction easier and more delightful. Virtue he represented as the harmony of the whole soul;—as a peace between all its principles and desires, assigning to each as much space as they can occupy, without encroaching on each other;—as a state of perfect health, in which every function was performed with ease, pleasure, and vigour;—as a well-ordered commonwealth, where the obedient passions executed with energy the laws and commands of reason. The vicious mind presented the odious character, sometimes of discord, of war;—sometimes of disease;—always of passions warring with each other in eternal anarchy. Consistent with himself, and at peace with his fellows, the good man felt in the quiet of his conscience a foretaste of the approbation of God. “Oh what ardent love would virtue inspire if she could be seen.” “If the heart of a tyrant could be laid bare, we should see how it was cut and torn by its own evil passions and by an avenging conscience.”[2]

Perhaps in every one of these illustrations, an eye trained in the history of Ethics may discover the germ of the whole or of a part of some subsequent theory. But to examine it thus would not be to look at it with the eye of Plato. His aim was as practical as that of Socrates. He employed every topic, without regard to its place in a system, or even always to its force as argument, which could attract the small portion of the community then accessible to cultivation; who, it should not be forgotten, had no moral instructor but the philosopher, unaided, if not thwarted, by the reigning superstition: for religion had not then, besides her own discoveries, brought down the most awful and the most beautiful forms of moral truth to the humblest station in human society.[3]

Ethics retained her sober spirit in the hands of his great scholar and rival Aristotle, who, though he certainly surpassed all men in acute distinction, in subtile argument, in severe method, in the power of analyzing what is most compounded, and of reducing to simple principles the most various and unlike appearances, yet appears to be still more raised above his fellows by the prodigious faculty of laying aside these extraordinary endowments whenever his present purpose required it; as in his History of Animals, in his Treatises on Philosophical Criticism, and in his Practical Writings, political as well as moral. Contrasted as his genius was to that of Plato, not only by its logical and metaphysical attributes, but by the regard to experience and observation of nature which, in him perhaps alone, accompanied them;—though they may be considered as the original representatives of the two antagonist tendencies of Philosophy—that which would ennoble man, and that which seeks rather to explain nature; yet opposite as they are in other respects, the master and the scholar combine to guard the Rule of Life against the licentious irruptions of the Sophists.

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[1] The most probable etymology of καλος seems to be from καω to burn. What burns commonly shines. *Schön*, in German, which means beautiful, is derived from *scheinen*, to shine. The word καλος was used for right, so early as the Homeric Poems. *Il.* xvii. 19. In the philosophical age it became a technical term, with little other remains of the metaphorical sense than what the genius and art of a fine writer might sometimes rekindle. *Honestum*, the term by which Cicero translates the καλον, being derived from outward honours, is a less happy metaphor. In our language, the terms being from foreign roots, contribute nothing to illustrate the progress of thought.

[2] Let it not be forgotten, that for this terrible description, Socrates, to whom it is ascribed by Plato (*De Rep.* ix.) is called “*Præstantissimus sapientiæ*,” by a writer of the most masculine understanding, the least subject to be transported by enthusiasm. (TAC. *Ann.* vi. 6.) “*Quæ vulnera!*” says Cicero, in alluding to the same passage. (*De Officiis*, iii. 21.)

[3] There can hardly be a finer example of Plato’s practical morals than his observations on the treatment of slaves. Genuine humanity and real probity, says he, are brought to the test, by the behaviour of a man to slaves, whom he may wrong with impunity. Διαδηλος γαρ ὁ φυσει και μη πλαστως σεβων την δικην, μισων δε οντως το αδικον εν τουτοις των ανθρωπων εν ὁις αυτῳ ῥᾳδιον αδικειν. (PLATO *de Legibus*, lib. vi. edit. Bipont. VIII. 303.)

That Plato was considered as the fountain of ancient morals, would be sufficiently evident from Cicero alone. “Ex hoc igitur Platonis, quasi quodam sancto augustoque fonte, nostra omnis manabit oratio.” (*Tusc. Quæst.* v. 13.) Perhaps the sober Quintilian meant to mingle some censure with the highest praise: “Plato, qui eloquendi facultate divina quadam et Homerica, multum supra prosam orationem surgit.” (*Inst. Orat.* x. 1.)

In Ethics alone their systems differed more in words than in things.[1] That happiness consisted in virtuous pleasure, chiefly dependent on the state of mind, but not unaffected by outward agents, was the doctrine of both. Both would with Socrates have called Happiness "unrepented Pleasure." Neither distinguished the two elements which they represented as constituting the supreme good from each other; partly, perhaps, from a fear of appearing to separate them. Plato more habitually considered happiness as the natural fruit of virtue; Aristotle oftener viewed virtue as the means of attaining happiness. The celebrated doctrine of the Peripatetics, which placed all virtues in a medium between opposite vices, was probably suggested by the Platonic representation of its necessity to keep up harmony between the different parts of our nature. The perfection of a compound machine is attained where all its parts have the fullest scope for action. Where one is so far exerted as to repress others, there is a vice of excess. When any one has less activity than it might exert without disturbing others, there is a vice of defect. The point which all reach without collision against each other, is the mediocrity in which the Peripatetics placed virtue.

It was not till near a century after the death of Plato that Ethics became the scene of philosophical contest between the adverse schools of Epicurus and Zeno; whose errors afford an instructive example, that in the formation of theory, partial truth is equivalent to absolute falsehood. As the astronomer who left either the centripetal or the centrifugal force of the planets out of his view, would err as completely as he who excluded both, so the Epicureans and Stoics, who each confined themselves to real but not exclusive principles in morals, departed as widely from the truth as if they had adopted no part of it. Every partial theory is indeed directly false, inasmuch as it ascribes to one or few causes what is produced by more. As the extreme opinions of one if not both of these schools have been often revived with variations and refinements in modern times, and are still not without influence on ethical systems, it may be allowable to make some observations on this earliest of moral controversies.

"All other virtues," said Epicurus, "grow from prudence, which teaches that we cannot live pleasurably without living justly and virtuously, nor live justly and virtuously without living pleasurably."[2] The illustration of this sentence formed the whole moral discipline of Epicurus. To him we owe the general concurrence of reflecting men in succeeding times, in the important truth, that men cannot be happy without a virtuous frame of mind and course of life; a truth of inestimable value, not peculiar to the Epicureans, but placed by their exaggerations in a stronger light;—a truth, it must be added, of less importance as a motive to right conduct than to the completeness of Moral Theory, which, however, it is very far from solely constituting. With that truth the Epicureans blended another position, which indeed is contained in the first words of the above statement; namely, that because virtue promotes happiness, every act of virtue must be done in order to promote the happiness of the agent. They and their modern followers tacitly assume, that the latter position is the consequence of the former; as if it were an inference from the necessity of food to life, that the fear of death should be substituted for the appetite of hunger as a motive for eating. "Friendship," says Epicurus, "is to be pursued by the wise man only for its usefulness, but he will begin as he sows the field in order to reap."[1] It is obvious, that if these words be confined to outward benefits, they may be sometimes true, but never can be pertinent; for outward acts sometimes show kindness, but never compose it. If they be applied to kind feeling they would indeed be pertinent, but they would be evidently and totally false; for it is most certain that no man acquires an affection merely from his belief that it would be agreeable or advantageous to feel it. Kindness cannot indeed be pursued on account of the pleasure which belongs to it; for man can no more know the pleasure till he has felt the affection, than he can form an idea of colour without the sense of sight. The moral character of Epicurus was excellent; no man more enjoyed the pleasure or better performed the duties of friendship. The letter of his system was no more indulgent to vice than that of any other moralist.[2] Although, therefore, he has the merit of having more strongly inculcated the connection of virtue with happiness, perhaps by the faulty excess of treating it as an exclusive principle; yet his doctrine was justly charged with indisposing the mind to those exalted and generous sentiments, without which no pure, elevated, bold, generous, or tender virtues can exist.[3]

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[1] "Una et consentiens duobus vocabulis philosophiæ forma instituta est, Academicorum et Peripateticorum; qui rebus congruentes, nominibus differebant." (CIC. *Acad. Quæst.* i. 4.) Βουλεται (Αριστοτελης) διττον ειναι τον κατα φιλοσοφιαν λογον· τον μεν πρακτικον, τον δε θεωρητικον. και του πρακτικου, τον τε ηθικον και πολιτικον· του δε θεωρητικου, τον τε φυσικον και λογικον. (DIOG. LAERT. v. 28.)

[2] EPIC. *Epist. ad Menœc.* apud DIOG. LAERT. lib. x. edit. Meibom. I. 658, 656.

As Epicurus represented the *tendency* of virtue, which is a most important truth in ethical theory, as the sole inducement to virtuous practice; so Zeno, in his disposition towards the opposite extreme, was inclined to consider the moral sentiments which are the motives of right conduct, as being the sole principles of moral science. The confusion was equally great in a philosophical view; but that of Epicurus was more fatal to interests of higher importance than those of philosophy. Had the Stoics been content with affirming that virtue is the source of all that part of our happiness which depends on ourselves, they would have taken a position from which it would have been impossible to drive them; they would have laid down a principle of as great comprehension in practice as their wider pretensions; a simple and incontrovertible truth, beyond which every thing is an object of mere curiosity to man. Our information, however, about the opinions of the more celebrated Stoics is very scanty. None of their own writings are preserved. We know little of them but from Cicero, the translator of Grecian philosophy, and from the Greek compilers of a later age; authorities which would be imperfect in the history of facts, but which are of far less value in the history of opinions, where a right conception often depends upon the minutest distinctions between words. We know that Zeno was more simple, and that Chrysippus, who was accounted the prop of the Stoic Porch, abounded more in subtile distinction and systematic spirit.[4] His power was attested as much by the antagonists whom he called forth, as by the scholars whom he formed. "Had there been no Chrysippus, there would have been no Carneades," was the saying of the latter philosopher himself; as it might have been said in the eighteenth century, "Had there been no Hume, there would have been no Kant and no Reid." Cleanthes, when one of his followers would pay court to him by laying vices to the charge of his most formidable opponent, Arcesilaus the academic, answered with a justice and candour unhappily too rare, "Silence,—do not malign him;—though he attacks virtue by his arguments, he confirms its authority by his life." Arcesilaus, whether modestly or churlishly, replied, "I do not choose to be flattered." Cleanthes, with a superiority of repartee, as well as charity, replied, "Is it flattery to say that you speak one thing and do another?" It would be vain to expect that the fragments of the Professors who lectured in the Stoic School for five hundred years, should be capable of being moulded into one consistent system; and we see that in Epictetus at least, the exaggeration of the sect was lowered to the level of reason, by confining the sufficiency of virtue to those cases only where happiness is attainable by our voluntary acts. It ought to be added, in extenuation of a noble error, that the power of habit and character to struggle against outward evils has been proved by experience to be in some instances so prodigious, that no man can presume to fix the utmost limit of its possible increase.

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[1] Την φιλιαν δια της χρειας. (Diog. Laert. *ibid.*) "Hic est locus," Gassendi confesses, "ob quem Epicurus non parum vexatur, quando nemo non reprehendit, parari amicitiam non sui, sed utilitatis gratia."

[2] It is due to him to observe, that he treated humanity towards slaves, as one of the characteristics of a wise man. Ουτε κολασειν οικετας, ελεησειν μεν τοι, και συγγνωμην τινι ἕξειν των σπουδαιων. (Diog. Laert. *ibid.* 653.) It is not unworthy of remark, that neither Plato nor Epicurus thought it necessary to abstain from these topics in a city full of slaves, many of whom were men not destitute of knowledge.

[3] "Nil generosum, nil magnificum sapit." Cicero.

[4] "Chrysippus, qui fulcire putatur porticum Stoicorum." Cicero. Elsewhere, "Acutissimus, sed in scribendo exilis et jejunus, scripsit rhetoricam seu potius obmutescendi artem;" nearly as we should speak of a Schoolman.

The attempt, however, of the Stoics to stretch the bounds of their system beyond the limits of nature, produced the inevitable inconvenience of dooming them to fluctuate between a wild fanaticism on the one hand, and, on the other, concessions which left their differences from other philosophers purely verbal. Many of their doctrines appear to be modifications of their original opinions, introduced as opposition became more formidable. In this manner they were driven to the necessity of admitting that the objects of our desires and appetites are worthy of preference, though they are denied to be constituents of happiness. It was thus that they were obliged to invent a double morality; one for mankind at large, from whom was expected no more than the ϰαθηϰον,—which seems principally to have denoted acts of duty done from inferior or mixed motives; and the other, which they appear to have hoped from their ideal wise man, is ϰατοϱθωμα, or perfect observance of rectitude,—which consisted only in moral acts done from mere reverence for morality, unaided by any feelings; all which (without the exception of pity) they classed among the enemies of reason and the disturbers of the human soul. Thus did they shrink from their proudest paradoxes into verbal evasions. It is remarkable that men so acute did not perceive and acknowledge, that if pain were not an evil, cruelty would not be a vice; and that if patience were of power to render torture indifferent, virtue must expire in the moment of victory. There can be no more triumph when there is no enemy left to conquer.[1]

The influence of men's opinions on the conduct of their lives is checked and modified by so many causes—it so much depends on the strength of conviction, on its habitual combination with feelings, on the concurrence or resistance of interest, passion, example, and sympathy—that a wise man is not the most forward in attempting to determine the power of its single operation over human actions. In the case of an individual it becomes altogether uncertain. But when the experiment is made on a large scale, when it is long continued and varied in its circumstances, and especially when great bodies of men are for ages the subject of it, we cannot reasonably reject the consideration of the inferences to which it appears to lead. The Roman Patriciate, trained in the conquest and government of the civilized world, in spite of the tyrannical vices which sprung from that training, were raised by the greatness of their objects to an elevation of genius and character unmatched by any other aristocracy; at the moment when, after preserving their power by a long course of wise compromise with the people, they were betrayed by the army and the populace into the hands of a single tyrant of their own order—the most accomplished of usurpers, and, if humanity and justice could for a moment be silenced, one of the most illustrious of men. There is no scene in history so memorable as that in which Cæsar mastered a nobility of which Lucullus and Hortensius, Sulpicius and Catulus, Pompey and Cicero, Brutus and Cato, were members. This renowned body had from the time of Scipio sought the Greek philosophy as an amusement or an ornament. Some few, "in thought more elevate," caught the love of truth, and were ambitious of discovering a solid foundation for the Rule of Life. The influence of the Grecian systems was tried by their effect on a body of men of the utmost originality, energy, and variety of character, during the five centuries between Carneades and Constantine, in their successive positions of rulers of the world, and of slaves under the best and under the worst of uncontrolled masters. If we had found this influence perfectly uniform, we should have justly suspected our own love of system of having in part bestowed that appearance on it. Had there been no trace of such an influence discoverable in so great an experiment, we must have acquiesced in the paradox, that opinion does not at all affect conduct. The result is the more satisfactory, because it appears to illustrate general tendency without excluding very remarkable exceptions. Though Cassius was an Epicurean, the true representative of that school was the accomplished, prudent, friendly, good-natured timeserver Atticus, the pliant slave of every tyrant, who could kiss the hand of Antony, imbrued as it was in the blood of Cicero. The pure school of Plato sent forth Marcus Brutus, the signal humanity of whose life was both necessary and sufficient to prove that his daring breach of venerable rules flowed only from that dire necessity which left no other means of upholding the most sacred principles. The Roman orator, though in speculative questions he embraced that mitigated doubt which allowed most ease and freedom to his genius, yet in those moral writings where his heart was most deeply interested, followed the severest sect of philosophy, and became almost a Stoic. If any conclusion may be hazarded from this trial of systems, the greatest which history has recorded, we must not refuse our decided though not undistinguishing preference to that noble school which preserved great souls untainted at the court of dissolute and ferocious tyrants; which exalted the slave of one of Nero's courtiers to be a moral teacher of aftertimes; which for the first, and hitherto for the only time, breathed philosophy and justice into those rules of law which govern the ordinary concerns of every man; and which, above all, has contributed, by the examples of Marcus Porcius Cato and of Marcus Aurelius Antoninus, to raise the dignity of our species, to keep alive a more ardent love of virtue, and a more awful sense of duty, throughout all generations.[1]

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[1] "Patience, sovereign o'er transmuted ill." But as soon as the ill was really "transmuted" into good, it is evident that there was no longer any scope left for the exercise of patience.

The result of this short review of the practical philosophy of Greece seems to be, that though it was rich in rules for the conduct of life, and in exhibitions of the beauty of virtue, and though it contains glimpses of just theory and fragments of perhaps every moral truth, yet it did not leave behind any precise and coherent system; unless we except that of Epicurus, who purchased consistency, method, and perspicuity too dearly by the sacrifice of truth, and by narrowing and lowering his views of human nature, so as to enfeeble, if not extinguish, all the vigorous motives to arduous virtue. It is remarkable, that while of the eight Professors who taught in the Porch, from Zeno to Posidonius, every one either softened or exaggerated the doctrines of his predecessor; and while the beautiful and reverend philosophy of Plato had, in his own Academy, degenerated into a scepticism which did not spare morality itself, the system of Epicurus remained without change; and his disciples continued for ages to show personal honours to his memory, in a manner which may seem unaccountable among those who were taught to measure propriety by a calculation of palpable and outward usefulness. This steady adherence is in part doubtless attributable to the portion of truth which the doctrine contains; in some degree perhaps to the amiable and unboastful character of Epicurus; not a little, it may be, to the dishonour of deserting an unpopular cause; but probably most of all to that mental indolence which disposes the mind to rest in a simple system, comprehended at a glance, and easily falling in, both with ordinary maxims of discretion, and with the vulgar commonplaces of satire on human nature.[1] When all instruction was conveyed by lectures, and when one master taught the whole circle of the sciences in one school, it was natural that the attachment of pupils to a Professor should be more devoted than when, as in our times, he can teach only a small portion of a knowledge spreading towards infinity, and even in his own little province finds a rival in every good writer who has treated the same subject. The superior attachment of the Epicureans to their master is not without some parallel among the followers of similar principles in our own age, who have also revived some part of that indifference to eloquence and poetry which may be imputed to the habit of contemplating all things in relation to happiness, and to (what seems its uniform effect) the egregious miscalculation which leaves a multitude of mental pleasures out of the account. It may be said, indeed, that the Epicurean doctrine has continued with little change to the present day; at least it is certain that no other ancient doctrine has proved so capable of being restored in the same form among the moderns; and it may be added, that Hobbes and Gassendi, as well as some of our own contemporaries, are as confident in their opinions, and as intolerant of scepticism, as the old Epicureans. The resemblance of modern to ancient opinions, concerning some of those questions upon which ethical controversy must always hinge, may be a sufficient excuse for a retrospect of the Greek morals; which it is hoped will simplify and shorten subsequent observation on those more recent disputes which form the proper subject of this discourse.

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[1] Of all testimonies to the character of the Stoics, perhaps the most decisive is the speech of the vile sycophant Capito, in the mock impeachment of Thrasea Pætus, before a senate of slaves: "Ut quondam C. Cæsarem et M. Catonem, ita nunc te, Nero, et Thraseam, avida discordiarum civitas loquitur...Ista secta Tuberones et Favonios, veteri quoque reipublicæ ingrata nomina, genuit." (Tacit. *Ann.* xvi. 22.)
See Notes and Illustrations, note A.

The genius of Greece fell with liberty. The Grecian philosophy received its mortal wound in the contests between scepticism and dogmatism which occupied the schools in the age of Cicero. The Sceptics could only perplex, and confute, and destroy. Their occupation was gone as soon as they succeeded. They had nothing to substitute for what they overthrew; and they rendered their own art of no further use. They were no more than venomous animals, who stung their victims to death, but also breathed their last into the wound. A third age of Grecian literature indeed arose at Alexandria, under the Macedonian kings of Egypt; laudably distinguished by exposition, criticism, and imitation, sometimes abused for the purposes of literary forgery, still more honoured by some learned and highly-cultivated poets, as well as by diligent cultivators of history and science; among whom some began about the first preaching of Christianity to turn their minds once more to that high philosophy which seeks for the fundamental principles of human knowledge. Philo, a learned and philosophical Hebrew, one of the flourishing colony of his nation established in that city, endeavoured to reconcile the Platonic Philosophy with the Mosaic Law and the Sacred Books of the Old Testament. About the end of the second century, when the Christians, Hebrews, Pagans, and various other sects of semi or Pseudo-Christian Gnostics appear to have studied in the same schools, the almost inevitable tendency of doctrines, however discordant, in such circumstances to amalgamate, produced its full effect under Ammonius Saccas; a celebrated Professor, who, by selection from the Greek systems, the Hebrew books, the oriental religions, and by some of that concession to the rising spirit of Christianity, of which the Gnostics had set the example, composed a very mixed system, commonly designated as the Eclectic Philosophy. The controversies between his contemporaries and followers, especially those of Clement and Origen, the victorious champions of Christianity, with Plotinus and Porphyry, who endeavoured to preserve Paganism by clothing it in a disguise of philosophical Theism, are, from the effects towards which they contributed, the most memorable in the history of human opinion.[1] But their connection with modern ethics is too faint to warrant any observation in this place, on the imperfect and partial memorials of them which have reached us. The death of Boethius in the west, and the closing of the Athenian schools by Justinian, may be considered as the last events in the history of ancient philosophy.[2]

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[1] The progress of commonplace satire on sexes or professions, and (he might have added) on nations, has been exquisitely touched by Gray in his Remarks on Lydgate; a fragment containing passages as finely thought and written as any in English prose. (GRAY's *Works*, Matthias's edition, vol. I. p. 55.) General satire on mankind is still more absurd; for no invective can be so unreasonable as that which is founded on falling short of an ideal standard.

SECTION III.

Retrospect of Scholastic Ethics.

An interval of a thousand years elapsed between the close of ancient and the rise of modern philosophy; the most unexplored, yet not the least instructive portion of the history of European opinion. In that period the sources of the institutions, the manners, the characteristic distinctions of modern nations, have been traced by a series of philosophical inquirers from Montesquieu to Hallam; and there also, it may be added, more than among the ancients, are the wellsprings of our speculative doctrines and controversies. Far from being inactive, the human mind, during that period of exaggerated darkness, produced discoveries in science, inventions in art, and contrivances in government, some of which, perhaps, were rather favoured than hindered by the disorders of society, and by the twilight in which men and things were seen. Had Boethius, the last of the ancients, foreseen, that within two centuries of his death, in the province of Britain, then a prey to all the horrors of barbaric invasion, a chief of one of the fiercest tribes of barbarians should translate into the jargon of his freebooters the work on *The Consolations of Philosophy*, of which the composition had soothed the cruel imprisonment of the philosophic Roman himself, he must, even amidst his sufferings, have derived some gratification from such an assurance of the recovery of mankind from ferocity and ignorance. But had he been allowed to revisit the earth in the middle of the sixteenth century, with what wonder and delight might he have contemplated the new and fairer order which was beginning to disclose its beauty, and to promise more than it revealed. He would have seen personal slavery nearly extinguished, and women, first released from oriental imprisonment by the Greeks, and raised to a higher dignity among the Romans,[3] at length fast approaching to due equality; two revolutions the most signal and beneficial since the dawn of civilisation. He would have seen the discovery of gunpowder, which for ever guarded civilized society against barbarians, while it transferred military strength from the few to the many; of paper and printing, which rendered a second destruction of the repositories of knowledge impossible, as well as opened a way by which it was to be finally accessible to all mankind; of the compass, by means of which navigation had ascertained the form of the planet, and laid open a new continent more extensive than his world. If he had turned to civil institutions, he might have learned that some nations had preserved an ancient, simple, and seemingly rude mode of legal proceeding, which threw into the hands of the majority of men a far larger share of judicial power than was enjoyed by them in any ancient democracy. He would have seen everywhere the remains of that principle of representation, the glory of the Teutonic race, by which popular government, anciently imprisoned in cities, became capable of being strengthened by its extension over vast countries, to which experience cannot even now assign any limits; and which, in times still distant, was to exhibit, in the newly-discovered continent, a republican confederacy, likely to surpass the Macedonian and Roman empires in extent, greatness, and duration, but gloriously founded on the equal rights, not like them on the universal subjection, of mankind. In one respect, indeed, he might have lamented that the race of man had made a really retrograde movement; that they had lost the liberty of philosophizing; that the open exercise of their highest faculties was interdicted. But he might also have perceived that this giant evil had received a mortal wound from Luther, who in his warfare against Rome had struck a blow against all human authority, and unconsciously disclosed to mankind that they were entitled, or rather bound, to form and utter their own opinions, and most of all on the most deeply interesting subjects: for although this most fruitful of moral truths was not yet so released from its combination with the wars and passions of the age as to assume a distinct and visible form, its action was already discoverable in the divisions among the Reformers, and in the fears and struggles of civil and ecclesiastical oppressors. The Council of Trent, and the Courts of Paris, Madrid, and Rome, had before that time foreboded the emancipation of reason.

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[1] The change attempted by Julian, Porphyry, and their friends, by which Theism would have become the popular religion, may be estimated by the memorable passage of Tacitus on the Theism of the Jews. In the midst of all the obloquy and opprobrium with which he loads that people, his tone suddenly rises when he comes to contemplate them as the only nation who paid religious honours to the supreme and eternal mind alone, and his style swells at the sight of so sublime and wonderful a scene. "Summum *illud* atque æternum, neque mutabile neque interiturum."

[2] The punishment of death was inflicted on Pagans by a law of Constantius. "Volumus cunctos sacrificiis abstinere. Si aliquid hujusmodi perpetraverint, gladio ultore sternantur." (Cod. I. tit. xi. *de Paganis*, A. D. 343 or 346.) From the authorities cited by Gibbon, (note, chap. xi.) as well as from some research, it should seem that the edict for the suppression of the Athenian schools was not admitted into the vast collection of laws enacted or systematized by Justinian.

[3] The steps of this important progress, as far as relates to Athens and Rome, are well remarked by one of the finest of the Roman writers. "Quem enim Romanorum pudet uxorem ducere in convivium? aut cujus materfamilias non primum locum tenet ædium, atque in celebritate versatur? quod multo fit aliter in Græcia; nam neque in convivium adhibetur, nisi propinquorum, neque sedet nisi in interiore parte ædium, quæ *Gynæconitis* appellatur, quo nemo accedit, nisi propinqua cognatione conjunctus." (Cornel. Nepos *in Præfat.*)

Though the middle age be chiefly memorable as that in which the foundations of a new order of society were laid, uniting the stability of the oriental system, without its inflexibility, to the activity of the Hellenic civilisation, without its disorder and inconstancy, yet it is not unworthy of notice, on account of the subterranean current which flows through it, from the speculations of ancient to those of modern times. That dark stream must be uncovered before the history of the European understanding can be thoroughly comprehended. It was lawful for the emancipators of reason in their first struggles to carry on mortal war against the Schoolmen. The necessity has long ceased; they are no longer dangerous; and it is now felt by philosophers that it is time to explore and estimate that vast portion of the history of philosophy from which we have scornfully turned our eyes.[1] A few sentences only can be allotted to the subject in this place. In the first moiety of the middle age, the darkness of Christendom was faintly broken by a few thinly-scattered lights. Even then, Moses Ben Maimon taught philosophy among the persecuted Hebrews, whose ancient schools had never perhaps been wholly interrupted; and a series of distinguished Mahometans, among whom two are known to us by the names of Avicenna and Averroes, translated the Peripatetic writings into their own language, expounded their doctrines in no servile spirit to their followers, and enabled the European Christians to make those versions of them from Arabic into Latin, which in the eleventh and twelfth centuries gave birth to the scholastic philosophy.

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[1] TENNEMAN, *Geschichte der Philosophie*, VIII. Band. 1811. COUSIN, *Cours de l'Histoire de la Philos.* p. 29. Paris, 1828. My esteem for this admirable writer encourages me to say, that the beauty of his diction has sometimes the same effect on his thoughts that a sunny haze produces on outward objects; and to submit to his serious consideration, whether the allurements of Schelling's system have not betrayed him into a too frequent forgetfulness that principles, equally adapted to all phenomena, furnish in speculation no possible test of their truth, and lead, in practice, to total indifference and inactivity respecting human affairs. I quote with pleasure an excellent observation from this work. "Le moyen âge n'est pas autre chose que la formation pénible, lente et sanglante, de tous les élémens de la civilisation moderne; je dis la formation, et non leur développement." (P. 27.)

The schoolmen were properly theologians, who employed philosophy only to define and support that system of Christian belief which they and their contemporaries had embraced. The founder of that theological system was Aurelius Augustinus,[1] (called by us Augustin) bishop of Hippo, in the province of Africa; a man of great genius and ardent character, who adopted at different periods of his life the most various, but at all times the most decisive and systematic, as well as daring and extreme opinions. This extraordinary man became, after some struggles, the chief Doctor, and for ages almost the sole oracle of the Latin church. It happened by a singular accident, that the schoolmen of the twelfth century, who adopted his theology, instead of borrowing their defensive weapons from Plato, the favourite of their master, had recourse for the exposition and maintenance of their doctrines to the writings of Aristotle, the least pious of philosophical theists. The Augustinian doctrines of original sin, predestination, and grace, little known to the earlier Christian writers, who appear indeed to have adopted opposite and milder opinions, were espoused by Augustin himself in his old age; when by a violent swing from his youthful Manicheism, which divided the sovereignty of the world between two adverse beings, he did not shrink, in his pious solicitude for tracing the power of God in all events, from presenting the most mysterious parts of the moral government of the universe, in their darkest colours and their sternest shape, as articles of faith, the objects of the habitual meditation and practical assent of mankind. The principles of his rigorous system, though not with all their legitimate consequences, were taught in the schools; respectfully promulgated rather than much inculcated by the western church (for in the East these opinions seem to have been unknown); scarcely perhaps distinctly assented to by the majority of the clergy; and seldom heard of by laymen till the systematic genius and fervid eloquence of Calvin rendered them a popular creed in the most devout and moral portion of the Christian world. Anselm,[2] the Piedmontese archbishop of Canterbury, was the earliest reviver of the Augustinian opinions. Aquinas[3] was their most redoubted champion. To them, however, the latter joined others of a different spirit. Faith, according to him, was a virtue, not in the sense in which it denotes the things believed, but in that in which it signifies the state of mind which leads to right belief. Goodness he regarded as the moving principle of the Divine government; justice, as a modification of goodness; and, with all his zeal to magnify the sovereignty of God, he yet taught, that though God always wills what is just, nothing is just solely because he wills it. Scotus,[4] the most subtile of doctors, recoils from the Augustinian rigour, though he rather intimates than avows his doubts. He was assailed for his tendency towards the Pelagian or Anti-Augustinian doctrines by many opponents, of whom the most famous in his time was Thomas Bradwardine,[5] archbishop of Canterbury, formerly confessor of Edward III., whose defence of predestination was among the most noted works of that age. He revived the principles of the ancient philosophers, who, from Plato to Marcus Aurelius, taught that error of judgment, being involuntary, is not the proper subject of moral disapprobation; which indeed is implied in Aquinas's account of faith.[6] But he appears to have been the first whose language inclined towards that most pernicious of moral heresies, which represents morality to be founded on will.[1] William of Ockham, the most justly celebrated of English schoolmen, went so far beyond this inclination of his master, as to affirm, that "if God had commanded his creatures to hate himself, the hatred of God would ever be the duty of man;" a monstrous hyperbole, into which he was perhaps betrayed by his denial of the doctrine of general ideas, the pre-existence of which in the Eternal intellect was commonly regarded as the foundation of the immutable nature of morality. The doctrine of Ockham, which by necessary implication refuses moral attributes to the Deity, and contradicts the existence of a moral government, is practically equivalent to atheism.[2] As all devotional feelings have moral qualities for their sole object; as no being can inspire love or reverence otherwise than by those qualities which are naturally amiable or venerable, this doctrine would, if men were consistent, extinguish piety, or, in other words, annihilate religion. Yet so astonishing are the contradictions of human nature, that this most impious of all opinions probably originated in a pious solicitude to magnify the sovereignty of God, and to exalt his authority even above his own goodness. Hence we may understand its adoption by John Gerson, the oracle of the Council of Constance, and the great opponent of the spiritual monarchy of the Pope; a pious mystic, who placed religion in devout feeling.[3] In further explanation, it may be added, that Gerson was of the sect of the Nominalists, of which Ockham was the founder; and that he was the more ready to follow his master, because they both courageously maintained the independence of the state on the church, and the authority of the church over the Pope. The general opinion of the schools was, however, that of Aquinas, who, from the native soundness of his own understanding, as well as from the excellent example of Aristotle, was averse from all rash and extreme dogmas on questions which had any relation, however distant, to the duties of life.

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[1] Notes and Illustrations, note B.

[2] Died in 1109.

[3] Born in 1224; died in 1279. Notes and Illustrations, note C.

[4] Born about 1265; died at Cologne (where his grave is still shown) in 1308. Whether he was a native of Dunston in Northumberland, or of Dunse in Berwickshire, or of Down in Ireland, was a question long and warmly contested, but which seems to be settled by his biographer, Luke Wadding, who quotes a passage of Scotus's Commentary on Aristotle's Metaphysics, where he illustrates his author thus: "As in the definition of St Francis, or St Patrick, man is necessarily presupposed." (SCOTI *Opera*, I. 3.) As Scotus was a Franciscan, the mention of St Patrick seems to show that he was an Irishman. Notes and Illustrations, note D.

[5] Born about 1290; died in 1349; the contemporary of Chaucer, and probably a fellow-student of Wicliffe and Roger Bacon. His principal work was entitled, *De Causa Dei contra Pelagium, et de Virtute Causarum, Libri III.*

[6] Notes and Illustrations, note E.

It is very remarkable, though hitherto unobserved, that Aquinas anticipated those controversies respecting perfect disinterestedness in the religious affections which occupied the most illustrious members of his communion[4] four hundred years after his death; and that he discussed the like question respecting the other affections of human nature with a fulness and clearness, an exactness of distinction, and a justness of determination, scarcely surpassed by the most acute of modern philosophers.[5] It ought to be added, that, according to the most natural and reasonable construction of his words, he allowed to the church a control only over spiritual concerns, and recognised the supremacy of the civil powers in all temporal affairs.[6]

It has already been stated that the scholastic system was a collection of dialectical subtilties, contrived for the support of the corrupted Christianity of that age, by a succession of divines, whose extraordinary powers of distinction and reasoning were morbidly enlarged in the long meditation of the cloister, by the exclusion of every other pursuit, and the consequent palsy of every other faculty; who were cut off from all the materials on which the mind can operate, and doomed for ever to toil in defence of what they must never dare to examine; to whom their age and their condition denied the means of acquiring literature, of observing nature, or of studying mankind. The few in whom any portion of imagination and sensibility survived this discipline, retired from the noise of debate, to the contemplation of pure and beautiful visions. They were called Mystics. The greater part, driven back on themselves, had no better employment than to weave cobwebs out of the terms of art which they had vainly, though ingeniously, multiplied. The institution of clerical celibacy, originating in an enthusiastic pursuit of purity, promoted by a mistake in moral prudence, which aimed at raising religious teachers in the esteem of their fellows, and at concentrating their whole minds on professional duties, at last, encouraged by the ambitious policy of the see of Rome, desirous of detaching them from all ties but her own, had the effect of shutting up all the avenues which Providence has opened for the entrance of social affection and virtuous feeling into the human heart. Though this institution perhaps prevented knowledge from becoming once more the exclusive inheritance of a sacerdotal caste; though the rise of innumerable laymen, of the lowest condition, to the highest dignities of the church, was the grand democratical principle of the middle age, and one of the most powerful agents in impelling mankind towards a better order; yet celibacy must be considered as one of the peculiar infelicities of these secluded philosophers; not only as it abridged their happiness, nor even solely, though chiefly, as it excluded them from the school in which the heart is humanized, but also (an inferior consideration, but more pertinent to our present purpose) because the extinction of these moral feelings was as much a subtraction from the moralist's store of facts and means of knowledge, as the loss of sight or of touch could prove to those of the naturalist.

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[1] Notes and Illustrations, note F.

[2] A passage to this effect, from Ockham, with nearly the same remark, has, since the text was written, been discovered on a re-perusal of Cudworth's *Immutable Morality*. See p. 10.

[3] "Remitto ad quod Occam de hac materia in Lib. Sentent. dicit, in qua explicatione si rudis judicetur, nescio quid appellabitur subtilitas." (GERSON *de Vita Spirit.* Op. III. 14. Hag. Com. 1728.)

[4] Bossuet and Fenelon.

[5] See AQUINAS, *Comm. in iii. Lib. Sentent.* distinctio xxix. quæst. i. art. 3. "Utrum Deus sit super omnia diligendus ex charitate." Art. 4. "Utrum in dilectione Dei possit haberi respectus ad aliquam mercedem." (*Opera*, IX. 322, 325.) Some illustrations of this memorable anticipation, which has escaped the research even of the industrious Tenneman. will be found in the Notes and Illustrations, note G.

[6] Notes and Illustrations, note H.

Neither let it be thought that to have been destitute of letters was to them no more than a want of ornament and a curtailment of gratification. Every poem, every history, every oration, every picture, every statue, is an experiment on human feeling, the grand object of investigation by the moralist. Every work of genius in every department of ingenious art and polite literature, in proportion to the extent and duration of its sway over the spirits of men, is a repository of ethical facts, of which the moral philosopher cannot be deprived by his own insensibility or by the iniquity of the times, without being robbed of the most precious instruments and invaluable materials of his science. Moreover, letters, which are closer to human feeling than science can ever be, have another influence on the sentiments with which the sciences are viewed, on the activity with which they are pursued, on the safety with which they are preserved, and even on the mode and spirit in which they are cultivated: they are the channels by which ethical science has a constant intercourse with general feeling. As the arts called useful maintain the popular honour of physical knowledge, so polite letters allure the world into the neighbourhood of the sciences of mind and of morals. Whenever the agreeable vehicles of literature do not convey their doctrines to the public, they are liable to be interrupted by the dispersion of a handful of recluse doctors, and the overthrow of their barren and unlamented seminaries. Nor is this all: these sciences themselves suffer as much when they are thus released from the curb of common sense and natural feeling, as the public loses by the want of those aids to right practice which moral knowledge in its sound state is qualified to afford. The necessity of being intelligible at least to all persons who join superior understanding to habits of reflection, who are themselves in constant communication with the far wider circle of intelligent and judicious men, which slowly but surely forms general opinion, is the only effectual check on the natural proneness of metaphysical speculations to degenerate into gaudy dreams or a mere war of words. The disputants who are set free from the wholesome check of sense and feeling, generally carry their dogmatism so far as to rouse the sceptic, who from time to time is provoked to look into the flimsiness of their cobwebs, and rushes in with his besom to sweep them and their systems into oblivion. It is true that literature, which thus draws forth moral science from the schools into the world, and recalls her from thorny distinctions to her natural alliance with the intellect and sentiments of mankind, may, in ages and nations otherwise situated, produce the contrary evil of rendering Ethics shallow, declamatory, and inconsistent. Europe at this moment affords, in different countries, specimens of these opposite and alike-mischievous extremes.

But we are now concerned only with the temptations and errors of the scholastic age.

We ought not so much to wonder at the mistakes of men so situated, as that they, without the restraints of the general understanding, and with the clogs of system and establishment, should in so many instances have opened questions untouched by the more unfettered ancients, and veins of speculation since mistakenly supposed to have been first explored in more modern times. Scarcely any metaphysical controversy agitated among recent philosophers was unknown to the schoolmen, unless we except that which relates to liberty and necessity, which would be an exception of doubtful propriety; for the disposition to it is clearly discoverable in the disputes of the Thomists and Scotists respecting the Augustinian and Pelagian doctrines,[1] although restrained from the avowal of legitimate consequences on either side by the theological authority which both parties acknowledged. The Scotists steadily affirmed the blamelessness of erroneous opinion; a principle which is the only effectual security for conscientious inquiry, for mutual kindness, and for public quiet. The controversy between the Nominalists and Realists, treated by some modern writers as an example of barbarous wrangling, was in truth an anticipation of that modern dispute which still divides metaphysicians, whether the human mind can form general ideas, and whether the words which are supposed to convey such ideas be not general terms, representing only a number of particular perceptions?—questions so far from frivolous, that they deeply concern both the nature of reasoning and the structure of language;—on which Hobbes, Berkeley, Hume, Stewart, and Tooke, have followed the Nominalists; and Descartes, Locke, Reid, and Kant, have, with various modifications and some inconsistencies, adopted the doctrine of the Realists.[2] With the schoolmen appears to have originated the form, though not the substance, of the celebrated maxim, which, whether true or false, is pregnant with systems, "There is nothing in the understanding which was not before in the senses."[3] Ockham[4] the Nominalist first denied the Peripatetic doctrine of the existence of certain species (since the time of Descartes called *ideas*) as the direct objects of perception and thought, interposed between the mind and outward objects; the modern opposition to which by Dr Reid has been supposed to justify the allotment of so high a station to that respectable philosopher. He taught also that we know nothing of mind but its acts, of which we are conscious. More inclination towards an independent philosophy is to be traced among the schoolmen than might be expected from their circumstances. Those who follow two guides will sometimes choose for themselves, and may prefer the subordinate on some occasions. Aristotle rivalled the church; and the church herself safely allowed considerable latitude to the philosophical reasonings of those who were only heard or read in colleges or cloisters, on condition that they neither impugned her authority, nor dissented from her worship, nor departed from the language of her creeds. The Nominalists were a freethinking sect, who, notwithstanding their defence of kings against the court of Rome, were persecuted by the civil power. It should not be forgotten that Luther was a Nominalist.[5]

If not more remarkable, it is more pertinent to our purpose, that the ethical system of the schoolmen, or, to speak more properly, of Aquinas, as the moral master of Christendom for three centuries, was in its practical part so excellent as to leave little need of extensive change, with the inevitable exception of the connection of his religious opinions with his precepts and counsels. His rule of life is neither lax nor impracticable. His grounds of duty are solely laid in the nature of man, and in the wellbeing of society. Such an intruder as subtilty seldom strays into his moral instructions. With a most imperfect knowledge of the Peripatetic writings, he came near the great master, by abstaining, in practical philosophy, from the unsuitable exercise of that faculty of distinction, in which he would probably have shown that he was little inferior to Aristotle if he had been equally unrestrained. His very frequent coincidence with modern moralists is doubtless to be ascribed chiefly to the nature of the subject; but in part also to that unbroken succession of teachers and writers, which preserved the observations contained in what had been long the text-book of the European schools, after the books themselves had been for ages banished and forgotten. The praises bestowed on Aquinas by every one of the few great men who appear to have examined his writings since the downfall of his power, among whom may be mentioned Erasmus, Grotius and Leibnitz, are chiefly, though not solely, referable to his ethical works.[1]

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[1] Notes and Illustrations, note I.

[2] Locke speaks on this subject inconsistently; Reid calls himself a Conceptualist; Kant uses terms so different that he ought perhaps to be considered as of neither party. Leibnitz, varying in some measure from the general spirit of his speculations, warmly panegyrizes the Nominalists: "Secta Nominalium, omnium inter scholasticos profundissima, et hodiernæ reformatæ philosophandi rationi congruentissima." (Leibn. *Op.* IV. Pars i. p. 59.)

[3] *Nil est in intellectu quod non prius fuit in sensu.*

[4] "Maximi vir ingenii, et eruditionis pro illo ævo summæ, Wilhelmus Occam, Anglus." (Leibn. *ibid.* p. 60.) The writings of Ockham, which are very rare, I have never seen. I owe my knowledge of them to Tenneman, who however quotes the words of Ockham, and of his disciple Biel.

[5] "In Martini Lutheri scriptis prioribus amor Nominalium satis elucet, donec in omnes monachos æqualiter affectus esse cœpit." (Leibn. IV. Pars i. p. 60.)

Though the schoolmen had thus anticipated many modern controversies of a properly metaphysical sort, they left untouched most of those questions of ethical theory which were unknown to, or neglected by the ancients. They do not appear to have discriminated between the nature of moral sentiments, and the criterion of moral acts; to have considered to what faculty of our mind moral approbation is referable; or to have inquired whether our moral faculty, whatever it may be, is implanted or acquired. Those who measure only by palpable results, have very consistently regarded the metaphysical and theological controversies of the schools as a mere waste of intellectual power. But the contemplation of the athletic vigour and versatile skill manifested by the European understanding, at the moment when it emerged from this tedious and rugged discipline, leads, if not to approbation, yet to more qualified censure. What might have been the result of a different combination of circumstances, is an inquiry which, on a large scale, is beyond human power. We may however venture to say, that no abstract science, unconnected with religion, was likely to be respected in a barbarous age; and we may be allowed to doubt whether any knowledge, dependent directly on experience, and applicable to immediate practice, would have so trained the European mind as to qualify it for that series of inventions, and discoveries, and institutions, which begins with the sixteenth century, and of which no end can now be foreseen but the extinction of the race of man.

The fifteenth century was occupied by the disputes of the Realists with the Nominalists, in which the scholastic doctrine expired. After its close no schoolman of note appeared. The sixteenth may be considered as the age of transition from the scholastic to the modern philosophy. The former, indeed, retained possession of the Universities, and was long after distinguished by all the ensigns of authority. But the mines were already prepared. The revolution in opinion had commenced. The moral writings of the preceding times had generally been commentaries on that part of the *Summa Theologiæ* of Aquinas which relates to Ethics. Though these still continued to be published, yet the most remarkable moralists of the sixteenth century indicated the approach of other modes of thinking, by the adoption of the more independent titles of Treatises on Justice and Law. These titles were suggested, and the spirit, contents, and style of the writings themselves, were materially affected by the improved cultivation of the Roman law, by the renewed study of ancient literature, and by the revival of various systems of Greek philosophy, now studied in the original, which at once mitigated and rivalled the scholastic doctors, and while they rendered philosophy more free, re-opened its communications with society and affairs. The speculative theology which had arisen under the French governments of Paris and London in the twelfth century, which flourished in the thirteenth in Italy in the hands of Aquinas, which was advanced in the British islands by Scotus and Ockham in the fourteenth, was, in the sixteenth, with unabated acuteness, but with a clearness and elegance unknown before the restoration of letters, cultivated by Spain, in that age the most powerful and magnificent of the European nations.

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[1] See especially the excellent Preface of Leibnitz to Nizolius, sect. 37.

Many of these writers treated the law of war and the practice of hostilities in a juridical form.[1] Francis Victoria, who began to teach at Valladolid in 1525, is said to have first expounded the doctrines of the schools in the language of the age of Leo the Tenth. Dominic Soto,[2] a Dominican, the confessor of Charles V., and the oracle of the Council of Trent, to whom that assembly were indebted for much of the precision and even elegance for which their doctrinal decrees are not unjustly commended, dedicated his treatise on *Justice and Law* to Don Carlos; in terms of praise which, used by a writer who is said to have declined the high dignities of the church, lead us to hope that he was unacquainted with the brutish vices of that wretched prince. It is a concise and not inelegant compound of the scholastic Ethics, which continued to be of considerable authority for more than a century.[3] Both he and his master Victoria deserve to be had in everlasting remembrance, for the part which they took on behalf of the natives of America and of Africa, against the rapacity and cruelty of the Spaniards. Victoria pronounced war against the Americans for their vices or for their paganism to be unjust.[4] Soto was the authority chiefly consulted by Charles V., on occasion of the conference held before him at Valladolid, in 1542, between Sepulveda, an advocate of the Spanish colonists, and Las Casas, the champion of the unhappy Americans; of which the result was a very imperfect edict of reformation in 1543, which, though it contained little more than a recognition of the principle of justice, almost excited a rebellion in Mexico. Sepulveda, a scholar and a reasoner, advanced many maxims which were specious, and in themselves reasonable, but which practically tended to defeat even the scanty and almost illusive reform which ensued. Las Casas was a passionate missionary, whose zeal, kindled by the long and near contemplation of cruelty, prompted him to exaggerations of fact and argument;[5] yet, with all its errors, it afforded the only hope of preserving the natives of America from extirpation. The opinion of Soto could not fail to be conformable to his excellent principle, that "there can be no difference between Christians and Pagans, for the law of nations is equal to all nations."[6] To Soto belongs the signal honour of being the first writer who condemned the African slave-trade. "It is affirmed," says he, "that the unhappy Ethiopians are by fraud or force carried away and sold as slaves. If this is true, neither those who have taken them, nor those who purchased them, nor those who hold them in bondage, can ever have a quiet conscience till they emancipate them, even if no compensation should be obtained."[7] As the work which contains this memorable condemnation of man-stealing and slavery was the substance of lectures many years delivered at Salamanca, philosophy and religion appear, by the hand of their faithful minister, to have thus smitten the monsters in their earliest infancy. It is hard for any man of the present age to conceive the praise which is due to the excellent monks who courageously asserted the rights of those whom they never saw, against the prejudices of their order, the supposed interest of their religion, the ambition of their government, the avarice and pride of their countrymen, and the prevalent opinions of their time.

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[1] Many of the separate dissertations, on points of this nature, are contained in the immense collection entitled *Tractatus Tractatuum*, published at Venice in 1584, under the patronage of the Roman see. There are three *de Bello;* one by Lupus of Segovia when Francis I. was prisoner in Spain; another, more celebrated, by Francis Arias, who, on the 11th June 1532, discussed before the College of Cardinals the legitimacy of a war by the Emperor against the Pope. There are two *de Pace;* and others *de Potestate Regia*, *de Pœna Mortis*, &c. The most ancient and scholastic is that of J. de Lignano of Milan *de Bello*. The above writers are mentioned in the Prolegomena to Grotius *de Jure Belli*. Pietro Belloni (Counsellor of the Duke of Savoy) *de Re Militari*, treats his subject with the minuteness of a Judge-Advocate, and has more modern examples, chiefly Italian, than Grotius.

[2] Born in 1494; died in 1560. (ANTONII *Bibliotheca Hispana Nova.*) The opinion of Soto's knowledge entertained by his contemporaries is expressed in a jingle, *Qui scit Sotum scit totum.*

[3] Notes and Illustrations, note K.

[4] "Indis non debere auferri imperium, ideo quia sunt peccatores, vel ideo quia non sunt Christiani," were the words of Victoria.

[5] Notes and Illustrations, note L.

[6] "Neque discrepantia (ut reor) est inter Christianos et infideles, quoniam ius gentium cunctis gentibus æquale est."

[7] SOTO *de Justitia et Jure*, lib. iv. quæst. ii. art. 2.

Francis Suarez,[1] a Jesuit, whose voluminous works amount to twenty-four volumes in folio, closes the list of writers of his class. His work on *Laws, and on God the Lawgiver*, may be added to the above treatise of Soto, as exhibiting the most accessible and perspicuous abridgement of the theological philosophy in its latest form.

Grotius, who, though he was the most upright and candid of men, could not have praised a Spanish Jesuit beyond his deserts, calls Suarez the most acute of philosophers and divines.[2] On a practical matter, which may be naturally mentioned here, though in strict method it belongs to another subject, the merit of Suarez is conspicuous. He first saw that international law was composed not only of the simple principles of justice applied to the intercourse between states, but of those usages, long observed in that intercourse by the European race, which have since been more exactly distinguished as the consuetudinary law acknowledged by the Christian nations of Europe and America.[3] On this important point his views are more clear than those of his contemporary Alberico Gentili.[4] It must even be owned, that the succeeding intimation of the same general doctrine by Grotius is somewhat more dark, perhaps from his excessive pursuit of concise diction.[5]

SECTION IV.

Modern Ethics.

The introduction to the great work of Grotius,[6] composed in the first years of his exile, and published at Paris in 1625, contains the most clear and authentic statement of the general principles of morals prevalent in Christendom after the close of the schools, and before the writings of Hobbes had given rise to those ethical controversies which more peculiarly belong to modern times. That he may lay down the fundamental principles of Ethics, he introduces Carneades on the stage as denying altogether the reality of moral distinctions; teaching that law and morality are contrived by powerful men for their own interest; that they vary in different countries, and change in successive ages; that there can be no natural law, since nature leads men as well as other animals to prefer their own interest to every other object; that therefore there is either no justice, or if there be, it is another name for the height of folly, inasmuch as it is a fond attempt to persuade a human being to injure himself for the unnatural purpose of benefiting his fellow-men.[1]

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[1] Born in 1538; died in 1617.

[2] "Tantæ subtilitatis philosophum et theologum, ut vix quemquam habeat parem." (Grotii *Epist.* apud Anton. *Bibl. Hisp. Nova.*)

[3] "Nunquam enim civitates sunt sibi tam sufficientes quin indigeant mutuo juvamine et societate, interdum ad majorem utilitatem, interdum ob necessitatem moralem. Hac igitur ratione indigent aliquo jure quo dirigantur et recte ordinentur in hoc genere societatis. Et quamvis magna ex parte hoc fiat per rationem naturalem, non tamen sufficienter et immediate quoad omnia, *ideoque specialia jura poterant usu earundem gentium introduci.*" (Suarez *de Legibus*, lib. ii. cap. ii. 9. *et seq.*)

[4] Born in the March of Ancona in 1550; died at London in 1608.

[5] Grotius *de Jure Belli*, lib. i. cap. i. sect. 14.

[6] *Prolegomena.* His letter to Vossius, of 1st August 1625, determines the exact period of the publication of this famous work. Grotii *Epist.* 74.

To this Grotius answered, that even inferior animals, under the powerful though transient impulse of parental love, prefer their young to their own safety or life; that gleams of compassion, and, he might have added, of gratitude and indignation, appear in the human infant long before the age of moral discipline; that man at the period of maturity is a social animal, who delights in the society of his fellow-creatures for its own sake, independently of the help and accommodation which it yields; that he is a reasonable being, capable of framing and pursuing general rules of conduct, of which he discerns that the observance contributes to a regular, quiet, and happy intercourse between all the members of the community; and that from these considerations all the precepts of morality, and all the commands and prohibitions of just law, may be derived by impartial reason. "And these principles," says the pious philosopher, "would have their weight, even if it were to be granted (which could not be conceded without the highest impiety) that there is no God, or that he exercises no moral government over human affairs."[2] "Natural law is the dictate of right reason, pronouncing that there is in some actions a moral obligation, and in other actions a moral deformity, arising from their respective suitableness or repugnance to the reasonable and social nature; and that consequently such acts are either forbidden or enjoined by God, the author of nature. Actions which are the subject of this exertion of reason, are in themselves lawful or unlawful, and are therefore as such necessarily commanded or prohibited by God."

Such was the state of opinion respecting the first principles of the moral sciences, when, after an imprisonment of a thousand years in the cloister, they began once more to hold intercourse with the general understanding of mankind. It will be seen in the laxity and confusion, as well as in the prudence and purity of this exposition, that some part of the method and precision of the schools was lost with their endless subtilties and their barbarous language. It is manifest that the latter paragraph is a proposition, not what it affects to be, a definition; that as a proposition it contains too many terms very necessary to be defined; that the purpose of the excellent writer is not so much to lay down a first principle of morals, as to exert his unmatched power of saying much in few words, in order to assemble within the smallest compass the most weighty inducements, and the most effectual persuasions to welldoing.

This was the condition in which ethical theory was found by Hobbes, with whom the present Dissertation should have commenced, if it had been possible to state modern controversies in a satisfactory manner, without a retrospect of the revolutions in opinion from which they in some measure flowed.

HOBBES.[3]

THOMAS HOBBES of Malmesbury may be numbered among those eminent persons born in the latter half of the sixteenth century, who gave a new character to European philosophy in the succeeding age.[4] He was one of the late writers and late learners. It was not till he was nearly thirty that he supplied the defects of his early education, by classical studies so successfully prosecuted, that he wrote well in the Latin then used by his scientific contemporaries; and made such proficiency in Greek as, in his earliest work, the Translation of Thucydides, published when he was forty, to afford a specimen of a version still valued for its remarkable fidelity; though written with a stiffness and constraint very opposite to the masterly facility of his original compositions. It was after forty that he learned the first rudiments of geometry (so miserably defective was his education); but yielding to the paradoxical disposition apt to infect those who begin to learn after the natural age of commencement, he exposed himself, by absurd controversies with the masters of a science which looks down with scorn on the Sophist. A considerable portion of his mature age was passed on the Continent, where he travelled as tutor to two successive Earls of Devonshire; a family with whom he seems to have passed near half a century of his long life. In France his reputation, founded at that time solely on personal intercourse, became so great, that his observations on the *Meditations* of Descartes were published in the works of that philosopher, together with those of Gassendi and Arnauld.[1] It was about his sixtieth year that he began to publish those philosophical writings which contain his peculiar opinions;—which set the understanding of Europe into general motion, and stirred up controversies among metaphysicians and moralists, not even yet determined. At the age of eighty-seven he had the boldness to publish metrical versions of the Iliad and Odyssey, which the greatness of his name, and the singularity of the undertaking, still render objects of curiosity, if not of criticism. He owed his influence to various causes; at the head of which may be placed that genius for system, which, though it cramps the growth of knowledge,[2] perhaps finally atones for that mischief, by the zeal and activity which it rouses among followers and opponents, who discover truth by accident, when in pursuit of weapons for their warfare. A system which attempts a task so hard as that of subjecting vast provinces of human knowledge to one or two principles, if it presents some striking instances of conformity to superficial appearances, is sure to delight the framer; and, for a time, to subdue and captivate the student too entirely for sober reflection and rigorous examination. The evil does not indeed very frequently recur. Perhaps Aristotle, Hobbes, and Kant, are the only persons who united in the highest degree the great faculties of comprehension and discrimination which compose the *Genius of System*. Of the three, Aristotle alone could throw it off where it was glaringly unsuitable; and it is deserving of observation, that the reign of system seems, from these examples, progressively to shorten in proportion as reason is cultivated and knowledge advances. But, in the first instance, consistency passes for truth. When principles in some instances have proved sufficient to give an unexpected explanation of facts, the delighted reader is content to accept as true all other deductions from the principles. Specious premises being assumed to be true, nothing more can be required than logical inference. Mathematical forms pass current as the equivalent of mathematical certainty. The unwary admirer is satisfied with the completeness and symmetry of the plan of his house—unmindful of the need of examining the firmness of the foundation and the soundness of the materials. The system-maker, like the conqueror, long dazzles and overawes the world; but when their sway is past, the vulgar herd, unable to measure their astonishing faculties, take revenge by trampling on fallen greatness.

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[1] The same commonplace paradoxes were retailed by the Sophists, whom Socrates is introduced as chastising in the Dialogues of Plato. They were common enough to be put by the historian into the mouth of an ambassador in a public speech. Ανδρι δε τυραννῳ η πολει αρχην εχουσῃ ουδεν αλογον ὁ τι ξυμφερον. (THUCYD. vi. 85.)

[2] "Et hæc quidem locum aliquem haberent, etiamsi daretur (quod sine summo scelere dari nequit) non esse Deum, aut non curari ab eo negotia humana." (*Proleg.* 11.) And in another place, "Jus naturale est dictatum rectæ rationis, indicans actui alicui, ex ejus convenientia aut disconvenientia cum ipsa natura rationali et sociali, inesse moralem turpitudinem aut necessitatem moralem, ac consequenter ab auctore naturæ Deo talem actum aut vetari aut præcipi. Actus de quibus tale exstat dictatum, debiti sunt aut illiciti per se, atque ideo a Deo necessario præcepti aut vetiti intelliguntur." (Lib. i. cap. i. sect. 10.)

[3] Born in 1588; died in 1679.

[4] Bacon, Descartes, Hobbes, and Grotius. The writings of the first are still as delightful and wonderful as they ever were, and his authority will have no end. Descartes forms an era in the history of Metaphysics, of Physics, of Mathematics. The controversies excited by Grotius have long ceased, but the powerful influence of his works will be doubted by those only who are unacquainted with the disputes of the seventeenth century.

The dogmatism of Hobbes was, however unjustly, one of the sources of his fame. The founders of systems deliver their novelties with the undoubting spirit of discoverers; and their followers are apt to be dogmatical, because they can see nothing beyond their own ground. It might seem incredible, if it were not established by the experience of all ages, that those who differ most from the opinions of their fellow-men are most confident of the truth of their own. But it commonly requires an overweening conceit of the superiority of a man's own judgment, to make him espouse very singular notions; and when he has once embraced them, they are endeared to him by the hostility of those whom he contemns as the prejudiced vulgar. The temper of Hobbes must have been originally haughty. The advanced age at which he published his obnoxious opinions, rendered him more impatient of the acrimonious opposition which they necessarily provoked; until at length a strong sense of the injustice of the punishment impending over his head, for the publication of what he believed to be truth, cooperated with the peevishness and timidity of his years, to render him the most imperious and morose of dogmatists. His dogmatism has indeed one quality more offensive than that of most others. Propositions the most adverse to the opinions of mankind, and the most abhorrent from their feelings, are introduced into the course of his argument with mathematical coldness. He presents them as demonstrated conclusions, without deigning to explain to his fellow-creatures how they all happened to believe the opposite absurdities; without even the compliment of once observing how widely his discoveries were at variance with the most ancient and universal judgments of the human understanding. The same quality in Spinoza indicates a recluse's ignorance of the world. In Hobbes it is the arrogance of a man who knows mankind and despises them.

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[1] The prevalence of freethinking under Louis XIII., to a far greater degree than it was avowed, appears not only from the complaints of Mersenne and of Grotius, but from the disclosures of Guy Patin; who, in his *Letters*, describes his own conversations with Gassendi and Naudé, so as to leave no doubt of their opinions.

[2] "Another error," says the Master of Wisdom, "is the over-early and peremptory reduction of knowledge into arts and methods, from which time commonly receives small augmentation." (Bacon's *Advancement of Learning*, book i.) "Method," says he, "carrying a show of total and perfect knowledge, has a tendency to generate acquiescence." What pregnant words!

A permanent foundation of his fame consists in his admirable style, which seems to be the very perfection of didactic language. Short, clear, precise, pithy, his language never has more than one meaning, which never requires a second thought to find. By the help of his exact method, it takes so firm a hold on the mind, that it will not allow attention to slacken. His little tract on *Human Nature* has scarcely an ambiguous or a needless word. He has so great a power of always choosing the most significant term, that he never is reduced to the poor expedient of using many in its stead. He had so thoroughly studied the genius of the language, and knew so well to steer between pedantry and vulgarity, that two centuries have not superannuated probably more than a dozen of his words. His expressions are so luminous, that he is clear without the help of illustration. Perhaps no writer of any age or nation, on subjects so abstruse, has manifested an equal power of engraving his thoughts on the mind of his readers. He seems never to have taken a word for ornament or pleasure; and he deals with eloquence and poetry as the natural philosopher who explains the mechanism of children's toys, or deigns to contrive them. Yet his style so stimulates attention, that it never tires; and, to those who are acquainted with the subject, appears to have as much spirit as can be safely blended with reason. He compresses his thoughts so unaffectedly, and yet so tersely, as to produce occasionally maxims which excite the same agreeable surprise with wit, and have become a sort of philosophical proverbs; the success of which he partly owed to the suitableness of such forms of expression to his dictatorial nature. His words have such an appearance of springing from his thoughts, as to impress on the reader a strong opinion of his originality, and indeed to prove that he was not conscious of borrowing; though conversation with Gassendi must have influenced his mind; and it is hard to believe that his coincidence with Ockham should have been purely accidental, on points so important as the denial of general ideas, the reference of moral distinctions to superior power, and the absolute thraldom of religion under the civil power, which he seems to have thought necessary, to maintain that independence of the state on the church with which Ockham had been contented.

His philosophical writings might be read without reminding any one that the author was more than an intellectual machine. They never betray a feeling except that insupportable arrogance which looks down on men as a lower species of beings; whose almost unanimous hostility is so far from shaking the firmness of his conviction, or even ruffling the calmness of his contempt, that it appears too petty a circumstance to require explanation, or even to merit notice. Let it not be forgotten, that part of his renown depends on the application of his admirable powers to expound truth when he meets it. This great merit is conspicuous in that part of his treatise of *Human Nature* which relates to the percipient and reasoning faculties. It is also very remarkable in many of his *secondary principles* on the subject of government and law, which, while the first principles are false and dangerous, are as admirable for truth as for his accustomed and unrivalled propriety of expression.[1] In many of these observations he even shows a disposition to soften his paradoxes, and to conform to the common sense of mankind.[2]

It was with perfect truth observed by my excellent friend Mr Stewart, that "the ethical principles of Hobbes are completely interwoven with his political system."[3] He might have said, that the whole of Hobbes's system, moral, religious, and in part philosophical, depended on his political scheme; not indeed logically, as conclusions depend on premises, but (if the word may be excused) *psychologically*, as the formation of one opinion may be influenced by a disposition to adapt it to previously cherished opinions. The Translation of Thucydides, as he himself boasts, was published to show the evils of popular government.[4] Men he represented as being originally equal, and having an equal right to all things, but as being taught by reason to sacrifice this right for the advantages of peace, and to submit to a common authority, which can preserve quiet, only by being the sole depositary of force, and must therefore be absolute and unlimited. The supreme authority cannot be sufficient for its purpose, unless it be wielded by a single hand; nor even then, unless his absolute power extends over religion, which may prompt men to discord by the fear of an evil greater than death. The perfect state of a community, according to him, is where law prescribes the religion and morality of the people, and where the will of an absolute sovereign is the sole fountain of law. Hooker had inculcated the simple truth, that "to live by one man's will is the cause of many men's misery." Hobbes embraced the daring paradox, that to live by one man's will is the only means of all men's happiness. Having thus rendered religion the slave of every human tyrant, it was an unavoidable consequence, that he should be disposed to lower her character, and lessen her power over men; that he should regard atheism as the most effectual instrument of preventing rebellion; at least that species of rebellion which prevailed in his time, and had excited his alarms. The formidable alliance of religion with liberty haunted his mind, and urged him to the bold attempt of rooting out both these mighty principles; which, when combined with interests and passions, when debased by impure support, and provoked by unjust resistance, have indeed the power of fearfully agitating society; but which are, nevertheless, in their own nature, and as far as they are unmixed and undisturbed, the fountains of justice, of order, of peace, as well as of those moral hopes, and of those glorious aspirations after higher excellence, which encourage and exalt the soul in its passage through misery and depravity. A Hobbist is the only consistent persecutor; for he alone considers himself as bound, by whatever conscience he has remaining, to conform to the religion of the sovereign.

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[1] See *De Corpore Politico*, Part i. chap. ii. iii. iv. and *Leviathan*, Part i. chap. xiv. xv. for remarks of this sort, full of sagacity.

[2] "The laws of nature are *immutable and eternal;* for injustice, ingratitude, arrogance, pride, iniquity, acception of persons, and the rest, can never be made lawful. For it can never be that war shall preserve life, and peace destroy it." (*Leviathan*, Part i. chap. xv. See also Part ii. chap. xxvi. xxviii. on Laws, and on Punishments.)

[3] See Dissertation First, p. 42. The political state of England is indeed said by himself to have occasioned his first philosophical publication.

Nascitur interea scelus execrabile belli.
..........................Horreo spectans,
Meque ad dilectam confero Lutetiam,
Postque duos annos edo De Cive Libellum. (*Vita* Hobbesii.)

[4] The speech of Euphemus in the 6th book of that historian, and the conference between the ministers from Athens and the Melean chiefs, in the 5th book, exhibit an undisguised *Hobbism*, which was very dramatically put into the mouth of Athenian statesmen at a time when, as we learn from Plato and Aristophanes, it was preached by the Sophists.

He claims from others no more than he is himself ready to yield to any master;[1] while the religionist who persecutes a member of another communion, exacts the sacrifice of conscience and sincerity, though professing that, rather than make it himself, he is prepared to die.

REMARKS.

The fundamental errors on which the ethical system of Hobbes is built are not peculiar to him; though he has stated them with a bolder precision, and placed them in a more conspicuous station in the van of his main force, than any other of those who have either frankly avowed or tacitly assumed them, from the beginning of speculation to the present moment. They may be shortly stated as follows.

1. The first and most inveterate of these errors is, that he does not distinguish *thought* from *feeling*, or rather that he in express words confounds them. The mere *perception* of an object, according to him, differs from the *pleasure* or *pain* which that perception may occasion, no otherwise than as they affect different organs of the bodily frame. The action of the mind in perceiving or conceiving an object is precisely the same with that of feeling the agreeable or disagreeable.[2] The necessary result of this original confusion is, to extend the laws of the intellectual part of our nature over that other part of it, hitherto without any adequate name, which feels, and desires, and loves, and hopes, and wills. In consequence of this long confusion, or want of distinction, it has happened that, while the simplest act of the merely intellectual part has many names, (such as sensation, perception, impression, &c.) the correspondent act of the other not less important portion of man is not denoted by a technical term in philosophical systems; nor by a convenient word in common language. *Sensation* has another more common sense. *Emotion* is too warm for a generic term. *Feeling* has some degree of the same fault, besides its liability to confusion with the sense of touch. *Pleasure* and *pain* represent only two properties of this act, which render its repetition the object of desire or aversion; which last states of mind presuppose the act. Of these words, *emotion* seems to be the least objectionable, since it has no absolute double meaning, and does not require so much vigilance in the choice of the accompanying words as would be necessary if we were to prefer *feeling;* which, however, being a more familiar word, may, with due caution, be also sometimes employed. Every man who attends to the state of his own mind will acknowledge, that these words, *emotion* and *feeling*, thus used, are perfectly simple, and as incapable of further explanation by words as sight or hearing; which may indeed be rendered into synonymous words, but never can be defined by any more simple or more clear. Reflection will in like manner teach that perception, reasoning, and judgment may be conceived to exist without being followed by emotion. Some men hear music without gratification: one may distinguish a taste without being pleased or displeased by it; or at least the relish or disrelish is often so slight, without lessening the distinctness of the sapid qualities, that the distinction of it from the perception cannot be doubted.

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[1] Spinoza adopted precisely the same first principle with Hobbes, that all men have a natural right to all things. (*Tractatus Politicus*, cap. ii. sect. 3.) He even avows the absurd and detestable maxim, that states are not bound to observe their treaties longer than the interest or danger which first formed the treaties continues. But on the internal constitution of states he embraces opposite opinions. *Servitutis enim non pacis interest omnem potestatem ad unum transferre.* (*Ibid.* cap. vi. sect. 4.) Limited monarchy he considers as the only tolerable example of that species of government. An aristocracy nearly approaching to the Dutch system during the suspension of the Stadtholdership, he seems to prefer. He speaks favourably of democracy, but the chapter on that subject is left unfinished. "Nulla plane templa urbium sumptibus ædificanda, nec jura de opinionibus statuenda." He was the first republican atheist of modern times, and probably the earliest irreligious opponent of an ecclesiastical establishment.

[2] This doctrine is explained in his tract on *Human Nature*, c. vii.–x. "*Conception is a motion* in some internal substance of the head, which proceeding to the heart, when it helpeth the motion there, it is called *pleasure;* when it weakeneth or hindereth the motion, it is called *pain.*" The same matter is handled more cursorily, agreeably to the practical purpose of the work, in *Leviathan*, Part i. chap. vi. These passages are here referred to as proofs of the statement in the text. With the materialism of it we have here no concern. If the multiplied suppositions were granted, we should not advance one step towards understanding what they profess to explain. The first four words are as unmeaning as if one were to say that greenness is very loud. It is obvious that many motions which promote the motion of the heart are extremely painful.

The multiplicity of errors which have flowed into Moral Science from this original confusion is very great. They have spread over many schools of philosophy; and many of them are prevalent to this day. Hence the laws of the understanding have been applied to the affections; virtuous feelings have been considered as just reasonings; evil passions represented as mistaken judgments; and it has been laid down as a principle, that the will always follows the last decision of the practical intellect.[1]

2. By this great error, Hobbes was led to represent all the variety of the desires of men, as being only so many instances of objects deliberately and solely pursued; because they were the means, and at the time perceived to be so, of directly or indirectly procuring organic gratification to the individual.[2] The human passions are described as if they reasoned accurately, deliberated coolly, and calculated exactly. It is assumed that, in performing these operations, there is and can be no act of life in which a man does not bring distinctly before his eyes the pleasure which is to accrue to himself from the act. From this single and simple principle, all human conduct may, according to him, be explained and even foretold.

The true laws of this part of our nature (so totally different from those of the percipient part) were, by this grand mistake, entirely withdrawn from notice. Simple as the observation is, it seems to have escaped not only Hobbes, but many, perhaps most philosophers, that our desires seek a great diversity of objects; that the attainment of these objects is indeed followed by, or rather called Pleasure; but that it could not be so, if the objects had not been previously desired. Many besides him have really represented *self* as the ultimate object of every action; but none ever so hardily thrust forward the selfish system in its harshest and coarsest shape. The mastery which he shows over other metaphysical subjects, forsakes him on this. He does not scruple, for the sake of this system, to distort facts of which all men are conscious; and to do violence to the language in which the result of their uniform experience is conveyed. "Acknowledgment of power is called Honour."[3] His explanations are frequently sufficient confutations of the doctrine which required them. "Pity is the imagination of future calamity to ourselves, proceeding from the sense (observation) of another man's calamity." "Laughter is occasioned by sudden glory in our eminence, or in comparison with the infirmity of others." Every man who ever wept or laughed, may determine whether this be a true account of the state of his mind on either occasion. "Love is a conception of his need of the one person desired;" a definition of love, which, as it excludes kindness, might perfectly well comprehend the hunger of a cannibal, provided that it were not too ravenous to exclude choice. "Good-will, or charity, which containeth the natural affection of parents to their children, consists in a man's conception that he is able not only to accomplish his own desires, but to assist other men in theirs:" from which it follows, as the pride of power is felt in destroying as well as in saving men, that cruelty and kindness are the same passion.[4]

Such were the expedients to which a man of the highest class of understanding was driven, in order to evade the admission of the simple and evident truth, that there are in our nature perfectly disinterested passions, which seek the wellbeing of others as their object and end, without looking beyond it to self, or pleasure, or happiness. A proposition, from which such a man could attempt to escape only by such means, may be strongly presumed to be true.

3. Hobbes having thus struck the affections out of his map of human nature, and having totally misunderstood (as will appear in a succeeding part of this Dissertation) the nature even of the appetites, it is no wonder that we should

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[1] "Voluntas semper sequitur ultimum indicium intellectus practici."

[2] See the passages before quoted.

[3] *Human Nature*, chap. viii. The ridiculous explanation of the admiration of personal beauty, "as a sign of power generative," shows the difficulties to which this extraordinary man was reduced by a false system.

[4] *Ibid.* chap. ix. I forbear to quote the passage on Platonic love, which immediately follows. But, considering Hobbes's blameless and honourable character, that passage is perhaps the most remarkable instance of the shifts to which his selfish system reduced him.

find in it not a trace of the moral sentiments. Moral good[1] he considers merely as consisting in the signs of a power to produce pleasure; and repentance is no more than regret at having missed the way: so that, according to this system, a disinterested approbation of, and reverence for virtue, are no more possible than disinterested affections towards our fellow-creatures. There is no sense of duty, no compunction for our own offences, no indignation against the crimes of others, unless they affect our own safety; no secret cheerfulness shed over the heart by the practice of welldoing. From his philosophical writings it would be impossible to conclude that there are in man a set of emotions, desires, and aversions, of which the sole and final objects are the voluntary actions and habitual dispositions of himself and of all other voluntary agents; which are properly called *Moral Sentiments;* and which, though they vary more in degree, and depend more on cultivation, than some other parts of human nature, are as seldom as most of them found to be entirely wanting.

4. A theory of man which comprehends in its explanations neither the social affections, nor the moral sentiments, must be owned to be sufficiently defective. It is a consequence, or rather a modification of it, that Hobbes should constantly represent the deliberate regard to personal advantage, as the only possible motive of human action; and that he should altogether disdain to avail himself of those refinements of the selfish scheme which allow the pleasures of benevolence and of morality, themselves, to be a most important part of that interest which reasonable beings pursue.

5. Lastly, though Hobbes does in effect acknowledge the necessity of morals to society, and the general coincidence of individual with public interest—truths so palpable that they never have been excluded from any ethical system—he betrays his utter want of moral sensibility by the coarse and odious form in which he has presented the first of these great principles; and his view of both leads him most strongly to support that common and pernicious error of moral reasoners, that a perception of the tendency of good actions to preserve the being and promote the wellbeing of the community, and a sense of the dependence of our own happiness upon the general security, either are essential constituents of our moral feelings, or are ordinarily mingled with the most effectual motives to right conduct.

The court of Charles II. were equally pleased with Hobbes's poignant brevity, and his low estimate of human motives. His ethical epigrams became the current coin of profligate wits. Sheffield, Duke of Buckinghamshire, who represented the class still more perfectly in his morals than in his faculties, has expressed their opinion in verses, of which one line is good enough to be quoted:

> Fame bears no fruit till the vain planter dies.

Dryden speaks of "the philosopher and *poet* (for such is the condescending term employed) of Malmesbury," as resembling Lucretius in haughtiness. But Lucretius, though he held many of the opinions of Hobbes, had the sensibility as well as genius of a poet. His dogmatism is full of enthusiasm; and his philosophical theory of society discovers occasionally as much tenderness as can be shown without reference to individuals. He was a Hobbist in only half his nature.

The moral and political system of Hobbes was a palace of ice, transparent, exactly proportioned, majestic, admired by the unwary as a delightful dwelling; but gradually undermined by the central warmth of human feeling, before it was thawed into muddy water by the sunshine of true philosophy.

When Leibnitz, in the beginning of the eighteenth century, reviewed the moral writers of modern times, his penetrating eye saw only two who were capable of reducing morals and jurisprudence to a science. "So great an enterprise," says he, "might have been executed by the deep-searching genius of Hobbes, if he had not set out from evil principles; or by the judgment and learning of the incomparable Grotius, if his powers had not been scattered over many subjects, and his mind distracted by the cares of an agitated life."[1] Perhaps in this estimate, admiration of the various and excellent qualities of Grotius may have overrated his purely philosophical powers, great as they unquestionably were. Certainly the failure of Hobbes was owing to no inferiority in strength of intellect. Probably his fundamental errors may be imputed, in part, to the faintness of his moral sensibilities, insufficient to make him familiar with those sentiments and affections which can be known only by being felt;—a faintness perfectly compatible with his irreproachable life, but which obstructed, and at last obliterated, the only channel through which the most important materials of ethical science enter into the mind.

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[1] Which he calls the *pulchrum*, for want, as he says, of an English word to express it. (*Leviathan*, Part i. c. vi.)

Against Hobbes, says Warburton, the whole church militant took up arms. The answers to the *Leviathan* would form a library. But the far greater part have followed the fate of all controversial pamphlets. Sir Robert Filmer was jealous of any rival theory of servitude. Harrington defended liberty, and Clarendon the church, against a common enemy. His philosophical antagonists were, Cumberland, Cudworth, Shaftesbury, Clarke, Butler, and Hutcheson. Though the last four writers cannot be considered as properly polemics, their labours were excited, and their doctrines modified, by the stroke from a vigorous arm which seemed to shake Ethics to its foundation. They lead us far into the eighteenth century; and their works, occasioned by the doctrines of Hobbes, sowed the seed of the ethical writings of Hume, Smith, Price, Kant, and Stewart; in a less degree, also, of those of Tucker and Paley: not to mention Mandeville, the buffoon and sophister of the ale-house; or Helvetius, an ingenious but flimsy writer, the low and loose moralist of the vain, the selfish, and the sensual.

SECTION V.

Controversies concerning the Moral Faculties and the Social Affections.

CUMBERLAND—CUDWORTH—CLARKE—SHAFTESBURY—BOSSUET—FENELON—LEIBNITZ—MALEBRANCHE—EDWARDS—BUFFIER.

Dr Richard Cumberland,[2] raised to the see of Peterborough after the revolution of 1688, was the only professed answerer of Hobbes. His work on *the Law of Nature* still retains a place on the shelf, though not often on the desk. The philosophical epigrams of Hobbes form a contrast to the verbose, prolix, and languid diction of his answerer. The forms of scholastic argument serve more to encumber his style than to insure his exactness. But he has substantial merits. He justly observes, that all men can only be said to have had originally a right to all things, in a sense in which right has the same meaning with power. He shows that Hobbes is at variance with himself; inasmuch as the dictates of right reason, which, by his own statement, teach men for their own safety to forego the exercise of that right, and which he calls *Laws of Nature*, are coeval with it; and that mankind perceive the moral limits of their power as clearly and as soon as they are conscious of its existence. He enlarges the intimations of Grotius on the social feelings, which prompt men to the pleasures of pacific intercourse, as certainly as the apprehension of danger and destruction urges them to avoid hostility. The fundamental principle of his Ethics is, that "the greatest benevolence of every rational agent to all others is the happiest state of each individual, as well as of the whole."[1] The happiness accruing to each man from the observance and cultivation of benevolence, he considers as appended to it by the supreme Ruler; through which he sanctions it as his law, and reveals it to the mind of every reasonable creature. From this principle he deduces the rules of morality, which he calls the *Laws of Nature.* The surest, or rather only mark that they are the commandments of God, is, that their observance promotes the happiness of man: for that reason alone could they be imposed by that Being whose essence is love. As our moral faculties must to us be the measure of all moral excellence, he infers that the moral attributes of the Divinity must in their nature be only a transcendent degree of those qualities which we most approve, love, and revere, in those moral agents with whom we are familiar.[2] He had a momentary glimpse of the possibility that some human actions might be performed with a view to the happiness of others, without any consideration of the pleasure reflected back on ourselves.[3] But it is too faint and transient to be worthy of observation, otherwise than as a new proof how often great truths must flit before the understanding, before they can be firmly and finally held in its grasp. His only attempt to explain the nature of the moral faculty, is the substitution of practical reason (a phrase of the schoolmen, since become celebrated from its renewal by Kant) for right reason;[4] and his definition of the first, as that which points out the ends and means of action. Throughout his whole reasoning, he adheres to the accustomed confusion of the quality which renders actions virtuous, with the sentiments excited in us by the contemplation of them. His language on the identity of general and individual interest is extremely vague; though it be, as he says, the foundation-stone of the Temple of Concord among men.

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[1] "Et tale aliquid potuisset vel ab incomparabilis Grotii judicio et doctrina, vel a profundo Hobbii ingenio præstari; nisi illum multa distraxissent; hic vero prava constituisset principia." (Leibnitii *Epist. ad Molanum*; IV. Pars iii. p. 276.)

[2] Born in 1632; died in 1718.

It is little wonder that Cumberland should not have disembroiled this ancient and established confusion, since Leibnitz himself, in a passage where he reviews the theories of morals which had gone before him, has done his utmost to perpetuate it. "It is a question," says he, "whether the preservation of human society be the first principle of the law of nature. This our author denies, in opposition to Grotius, who laid down sociability to be so; to Hobbes, who ascribed that character to mutual fear; and to Cumberland, who held that it was mutual benevolence; which are all three only different names for the safety and welfare of society."[5] Here the great philosopher considered benevolence or fear, two feelings of the human mind, to be the first principles of the law of nature; in the same sense in which the tendency of certain actions to the wellbeing of the community may be so regarded. The confusion, however, was then common to him with many, as it even now is with most. The comprehensive view was his own. He perceives the close resemblance of these various and even conflicting opinions, in that important point of view in which they relate to the effects of moral and immoral actions on the general interest. The tendency of virtue to preserve amicable intercourse was enforced by Grotius; its tendency to prevent injury was dwelt on by Hobbes; its tendency to promote an interchange of benefits was inculcated by Cumberland.

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[1] CUMBERLAND *de Legibus Naturæ*, cap. i. sect. 12. first published in London, 1672, and then so popular as to be reprinted at Lubeck in 1683.

[2] *Ibid.* cap. v. sect. 19.

[3] *Ibid.* cap. ii. sect. 20.

[4] "Whoever determines his judgment and his will by right reason, must agree with all others who judge according to right reason in the same matter." (*Ibid.* cap. ii. sect. 8.) This is in one sense only a particular instance of the identical proposition, that two things which agree with a third thing must agree with each other in that in which they agree with the third. But the difficulty entirely consists in the particular third thing here introduced, namely, "right reason," the nature of which not one step is made to explain. The position is curious, as coinciding with "the universal categorical imperative," adopted as a first principle by Kant.

[5] LEIBN. IV. Pars iii. p. 271. The unnamed work which occasioned these remarks (perhaps one of Thomasius) appeared in 1699. How long after this Leibnitz's Dissertation was written, does not appear.

CUDWORTH.[1]

Cudworth, one of the eminent men educated or promoted in the English Universities during the Puritan rule, was one of the most distinguished of the Latitudinarian or Arminian party who came forth at the Restoration, with a love of liberty imbibed from their Calvinistic masters, as well as from the writings of antiquity, yet tempered by the experience of their own agitated age; and with a spirit of religious toleration more impartial and mature, though less systematic and professedly comprehensive, than that of the Independents, the first sect who preached that doctrine. Taught by the errors of their time, they considered religion as consisting, not in vain efforts to explain unsearchable mysteries, but in purity of heart exalted by pious feelings, and manifested by virtuous conduct.[2] The government of the church was placed in their hands by the revolution, and their influence was long felt among its rulers and luminaries. The first generation of their scholars turned their attention too much from the cultivation of the heart to the mere government of outward action; and in succeeding times the tolerant spirit, not natural to an establishment, was with difficulty kept up by a government whose existence depended on discouraging intolerant pretensions. No sooner had the first sketch of the Hobbian philosophy[3] been privately circulated at Paris, than Cudworth seized the earliest opportunity of sounding the alarm against the most justly odious of the modes of thinking which it cultivates, or forms of expression which it would introduce;[4] the prelude to a war which occupied the remaining forty years of his life. The *Intellectual System*, his great production, is directed against the atheistical opinions of Hobbes: it touches ethical questions but occasionally and incidentally. It is a work of stupendous erudition, of much more acuteness than at first appears, of frequent mastery over diction and illustration on subjects where it is most rare; and it is distinguished, perhaps beyond any other volume of controversy, by that best proof of the deepest conviction of the truth of a man's principles, a fearless statement of the most formidable objections to them; a fairness rarely practised but by him who is conscious of his power to answer them. In all his writings, it must be owned, that his learning obscures his reasonings, and seems even to oppress his powerful intellect. It is an unfortunate effect of the redundant fulness of his mind, that it overflows in endless digressions, which break the chain of argument, and turn aside the thoughts of the reader from the main object. He was educated before usage had limited the naturalization of new words from the learned languages; before the failure of those great men, from Bacon to Milton, who laboured to follow a Latin order in their sentences,—and the success of those men of inferior powers, from Cowley to Addison, who were content with the order, as well as the words, of pure and elegant conversation,—had, as it were, by a double series of experiments, ascertained that the involutions and inversions of the ancient languages are seldom reconcilable with the genius of ours; and, unless skilfully, as well as sparingly introduced, are at variance with the natural beauties of our prose composition. His mind was more that of an ancient than of a modern philosopher. He often indulged in that sort of amalgamation of fancy with speculation, the delight of the Alexandrian doctors, with whom he was most familiarly conversant; and the *Intellectual System*, both in thought and expression, has an old and foreign air, not unlike a translation from the work of a later Platonist. Large ethical works of this eminent writer are extant in manuscript in the British Museum.[1] One posthumous volume on morals was published by Dr Chandler, bishop of Durham, entitled, *A Treatise concerning Eternal and Immutable Morality.*[2] But there is the more reason to regret (as far as relates to the history of opinion) that the larger treatises are still unpublished, because the above volume is not so much an ethical treatise as an introduction to one. Protagoras of old, and Hobbes then alive, having concluded that right and wrong were unreal, because they were not perceived by the senses, and because all human knowledge consists only in such perception, Cudworth endeavours to refute them, by disproving that part of their premises which forms the last-stated proposition. The mind has many conceptions (*νοηματα*) which are not cognizable by the senses; and though they are *occasioned* by sensible objects, yet could not be formed but by a faculty superior to sense. The conceptions of justice and duty he places among them. The distinction of right from wrong is discerned by reason; and as soon as these words are defined, it becomes evident that it would be a contradiction in terms to affirm that any power, human or divine, could change their nature; or, in other words, make the same act to be just and unjust at the same time. They had existed eternally, in the only mode in which truths can be said to be eternal, in the Eternal Mind; and they were indestructible and unchangeable like that Supreme Intelligence.[3]

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[1] Born in 1617; died in 1688.

[2] See the beautiful account of them by Burnet, (*Hist.* I. 321, Oxford edit. 1823) who was himself one of the most distinguished of this excellent body; with whom may be classed, notwithstanding some shades of doctrinal difference, his early master, Leighton, bishop of Dunblane, a beautiful writer, and one of the best of men. The earliest account of them is in a curious contemporary pamphlet, entitled, *An Account of the new Sect of Latitude-men at Cambridge*, republished in the collection of tracts entitled, *Phœnix Britannicus.* Jeremy Taylor deserves the highest and perhaps the earliest place among them. But Cudworth's excellent sermon before the House of Commons (31st March 1647) in the year of the publication of Taylor's *Liberty of Prophesying*, may be compared even to Taylor in charity, piety, and the most liberal toleration.

[3] *De Cive*, 1642.

[4] *Dantur boni et mali rationes æternæ et indispensabiles. Thesis* for the degree of B. D. at Cambridge in 1644. (Birch's *Life of Cudworth*, prefixed to his edition of the *Intellectual System*, p. vii. Lond. 1743. 2 vols. 4to.)

Whatever judgment may be formed of this reasoning, it is manifest that it relates merely to the philosophy of the *understanding*, and does not attempt any explanation of what constitutes the very essence of morality, its relation to the *will.* That we perceive a distinction between right and wrong as much as between a triangle and a square, is indeed true; and may possibly lead to an explanation of the reason why men should adhere to the one and avoid the other. But it is not that reason. A command or a precept is not a proposition. It cannot be said that either is true or false. Cudworth, as well as many who succeeded him, confounded the mere apprehension by the understanding that right is different from wrong, with the practical authority of these important conceptions, exercised over voluntary actions, in a totally distinct province of the human soul.

Though his life was devoted to the assertion of divine Providence, and though his philosophy was imbued with the religious spirit of Platonism,[4] yet he had placed Christianity too purely in the love of God and man to be considered as having much regard for those controversies about rites and opinions with which zealots disturb the world. They represented him as having fallen into the same heresy with Milton and with Clarke;[5] and some of them even charged him with atheism, for no other reason than that he was not afraid to state the atheistic difficulties in their fullest force. As blind anger heaps inconsistent accusations on each other, they called him at least "an Arian, a Socinian, or a Deist."[6] The courtiers of Charles II., who were delighted with every part of Hobbes but his integrity, did their utmost to decry his antagonist. They turned the railing of the bigots into a sarcasm against religion; as we learn from him who represented them with unfortunate fidelity. "He has raised," says Dryden, "such strong objections against the being of God, that many think he has not answered them;"—"the common fate," as Lord Shaftesbury tells us, "of those who dare to appear fair authors."[1] He had, indeed, earned the hatred of some theologians, better than they could know from the writings published during his life; for in his posthumous work he classes with the ancient atheists those of his contemporaries, whom he forbears to name, who held "that God may command what is contrary to moral rules; that he has no inclination to the good of his creatures; that he may justly doom an innocent being to eternal torments; and that whatever God does will, for that reason is just, because he wills it."[2] It is an interesting incident in the life of a philosopher, that Cudworth's daughter, Lady Masham, had the honour to nurse the infirmities and to watch the last breath of Mr Locke, who was opposed to her father in speculative philosophy, but who heartily agreed with him in the love of truth, liberty, and virtue.

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[1] A curious account of the history of these MSS. by Dr Kippis, is to be found in the *Biographia Britannica*, IV. 549.

[2] London, 1731, 8vo.

[3] "There are many objects of our mind which we can neither see, hear, feel, smell, nor taste, and which did never enter into it by any sense; and therefore we can have no sensible pictures or ideas of them, drawn by the pencil of that inward limner or painter which borrows all his colours from sense, which we call Fancy: and if we reflect on our own cogitations of these things, we shall sensibly perceive that they are not *phantastical*, but *noematical*: as, for example, justice, equity, duty and obligation, cogitation, opinion, intellection, volition, memory, verity, falsity, cause, effect, genus, species, nullity, contingency, possibility, impossibility, and innumerable others." (*Eternal and Immutable Morality*, p. 140.) We have here an anticipation of Kant.

[4] *Ευσεβει, ω τεκνον, ὁ γαρ ευσεβων ακρως χριστιανιζει.* Be pious, my son, for piety is the sum of Christianity. (Motto affixed to the sermon above mentioned.)

[5] The following doctrine is ascribed to Cudworth by Nelson, a man of good understanding and great worth: "Dr Cudworth maintained that the Father, absolutely speaking, is the only supreme God; the Son and Spirit being God only by his concurrence with them, and their subordination and subjection to him." (NELSON's *Life of Bull*, p. 339.)

[6] TURNER's *Discourse on the Messiah*, p. 335.

CLARKE.[3]

CONNECTED with Cudworth by principle, though separated by some interval of time, was Dr Samuel Clarke, a man eminent at once as a divine, a mathematician, a metaphysical philosopher, and a philologer; who, as the interpreter of Homer and Cæsar, the scholar of Newton, and the antagonist of Leibnitz, approved himself not unworthy of correspondence with the highest order of human spirits. Roused by the prevalence of the doctrines of Spinoza and Hobbes, he endeavoured to demonstrate the being and attributes of God, from a few axioms and definitions, in the manner of geometry; an attempt in which, with all his powers of argument, it must be owned that he is compelled sometimes tacitly to assume what the laws of reasoning required him to prove; and that, on the whole, his failure may be regarded as a proof that such a mode of argument is beyond the faculties of man.[4] Justly considering the moral attributes of the Deity as what alone renders him the object of religion, and to us constitutes the difference between theism and atheism, he laboured with the utmost zeal to place the distinctions of right and wrong on a more solid foundation; and to explain the conformity of morality to reason, in a manner calculated to give a precise and scientific signification to that phraseology which all philosophers had, for so many ages, been content to employ, without thinking themselves obliged to define.

It is one of the most rarely successful efforts of the human mind, to place the understanding at the point from which a philosopher takes the views that compose his system, to recollect constantly his purposes, to adopt for a moment his previous opinions and prepossessions, to think in his words and to see with his eyes; especially when the writer widely dissents from the system which he attempts to describe, and after a general change in the modes of thinking and in the use of terms. Every part of the present Dissertation requires such an excuse; but perhaps it may be more necessary in a case like that of Clarke, where the alterations in both respects have been so insensible, and in some respects appear so limited, that they may escape attention, than after those total revolutions in doctrine, where the necessity of not measuring other times by our own standard must be apparent to the most undistinguishing.

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[1] *Moralists*, Part ii. sect. 3.

[2] *Eternal and Immutable Morality*, p. 11. He names only one book published at Franeker. He quotes Ockham as having formerly maintained the same monstrous positions. To many, if not to most of these opinions or expressions, ancient and modern, reservations are adjoined, which render them *literally* reconcilable with practical morals. But the dangerous abuse to which the incautious language of ethical theories is liable, is well illustrated by an anecdote related in Plutarch's Life of Alexander. A sycophant named Anaxarchas consoled that monarch for the murder of Clitus, by assuring him that every act of a ruler must be just. Παν το πϱαχθεν ὑπο του κϱατουντος δικαιον. (PLUT. *Oper*. I. 639. Franc. 1599.)

[3] Born in 1675; died in 1729.

[4] This admirable person had so much candour as in effect to own his failure, and to recur to those other arguments in support of this great truth, which have in all ages satisfied the most elevated minds. In Proposition viii. (*Being and Attributes of God*, p. 47) which affirms that the first cause *must* be "intelligent," (where, as he truly states, "lies the main question between us and the atheists") he owns, that the proposition cannot be demonstrated strictly and properly *a priori*.
See Notes and Illustrations, note M.

The sum of his moral doctrine may be stated as follows. Man can conceive nothing without at the same time conceiving its relations to other things. He must ascribe the same law of perception to every being to whom he ascribes thought. He cannot therefore doubt that all the relations of all things to all must have always been present to the Eternal Mind. The relations in this sense are eternal, however recent the things may be between whom they subsist. The whole of these relations constitute truth. The knowledge of them is omniscience. These eternal *different* relations of things involve a consequent eternal *fitness* or *unfitness* in the application of things one to another; with a regard to which, the will of God always chooses, and which ought likewise to determine the wills of all subordinate rational beings. These eternal differences make it fit and reasonable for the creatures so to act; they cause it to be their duty, or lay an *obligation* on them so to do, separate from the will of God,[1] and antecedent to any prospect of advantage or reward.[2] Nay, wilful wickedness is the same absurdity and insolence in morals, as it would be in natural things to pretend to alter the relations of numbers, or to take away the properties of mathematical figures.[3] "Morality," says one of his most ingenious scholars, "is the practice of reason."[4]

Clarke, like Cudworth, considered such a scheme as the only security against Hobbism, and probably against the Calvinistic theology, from which they were almost as averse. Not content, with Cumberland, to attack Hobbes on ground which was in part his own, they thought it necessary to build on entirely new foundations. Clarke more especially, instead of substituting social and generous feeling for the selfish appetites, endeavoured to bestow on morality the highest dignity, by thus deriving it from reason. He made it more than disinterested; for he placed its seat in a region where interest never enters, and passion never disturbs. By ranking her principles with the first truths of science, he seemed to render them pure and impartial, infallible and unchangeable. It might be excusable to regret the failure of so noble an attempt, if the indulgence of such regrets did not betray an unworthy apprehension that the same excellent ends could only be attained by such frail means; and that the dictates of the most severe reason would not finally prove reconcilable with the majesty of virtue.

REMARKS.

The adoption of mathematical forms and terms was, in England, a prevalent fashion among writers on moral subjects during a large part of the eighteenth century. The ambition of mathematical certainty, on matters concerning which it is not given to man to reach it, is a frailty from which the disciple of Newton ought in reason to have been withheld, but to which he was naturally tempted by the example of his master. Nothing but the extreme difficulty of detaching assent from forms of expression to which it has been long wedded, can explain the fact, that the incautious expressions above cited, into which Clarke was hurried by his moral sensibility, did not awaken him to a sense of the error into which he had fallen. As soon as he had said that "a wicked act was as absurd as an attempt to take away the properties of a figure," he ought to have seen, that principles which led logically to such a conclusion were untrue. As it is an impossibility to make three and three cease to be six, it ought, on his principles, to be impossible to do a wicked act. To act without regard to the relations of things, as if a man were to choose fire for cooling, or ice for heating, would be the part either of a lunatic or an idiot. The murderer who poisons by arsenic, acts agreeably to his knowledge of the power of that substance to kill, which is a relation between two things;

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[1] "Those who found all moral obligation on the will of God must recur to the same thing, only they do not explain how the nature and will of God is good and just." (*Being and Attributes of God*, Proposition xii.)

[2] *Evidence of Natural and Revealed Religion*, p. 4, 6th edit. Lond. 1724.

[3] *Ibid.* p. 42.

[4] LOWMAN *on the Unity and Perfections of God*, p. 29. Lond. 1737.

as much as the physician who employs an emetic after the poison, acts upon his belief of the tendency of that remedy to preserve life, which is another relation between two things. All men who seek a good or bad end by good or bad means, must alike conform their conduct to some relation between their actions as means and their object as an end. All the relations of inanimate things to each other are undoubtedly observed as much by the criminal as by the man of virtue.

It is therefore singular that Dr Clarke suffered himself to be misled into the representation, that virtue is a conformity with the relations of things universally, vice a universal disregard of them, by the certain, but here insufficient truth, that the former necessarily implied a regard to *certain particular relations*, which were always disregarded by those who chose the latter. The distinction between right and wrong can, therefore, no longer depend on relations as such, but on a particular class of relations. And it seems evident that no relations are to be considered, except those in which a living, intelligent, and voluntary agent is one of the beings related. His acts may relate to a law, as either observing or infringing it; they may relate to his own moral sentiments and those of his fellows, as they are the objects of approbation or disapprobation; they may relate to his own welfare, by increasing or abating it; they may relate to the wellbeing of other sentient beings, by contributing to promote or obstruct it: but in all these, and in all supposable cases, the inquiry of the moral philosopher must be, not whether there be a relation, but what the relation is; whether it be that of obedience of law, or agreeableness to moral feeling, or suitableness to prudence, or coincidence with benevolence. The term *relation* itself, on which Dr Clarke's system rests, being common to right and wrong, must be struck out of the reasoning. He himself incidentally drops intimations which are at variance with his system. "The Deity," he tells us, "acts according to the eternal relations of things, in order to the welfare of the whole universe;" and subordinate moral agents ought to be governed by the same rules, "for the good of the public."[1] No one can fail to observe that a new element is here introduced—the wellbeing of communities of men, and the general happiness of the world—which supersedes the consideration of abstract relations and fitnesses.

There are other views of this system, however, of a more general nature, and of much more importance, because they extend in a considerable degree to all systems which found moral distinctions or sentiments, solely or ultimately, upon reason. A little reflection will discover an extraordinary vacuity in this system. Supposing it were allowed that it satisfactorily accounts for moral judgments, there is still an important part of our moral sentiments which it passes by without an attempt to explain them. Whence, on this scheme, the pleasure or pain with which we review our own actions, or survey those of others? What is the nature of remorse? Why do we feel shame? Whence is indignation against injustice? These are surely no exercise of reason. Nor is the assent of reason to any other class of propositions followed or accompanied by emotions of this nature, by any approaching them, or indeed necessarily by any emotion at all. It is a fatal objection to a moral theory, that it contains no means of explaining the most conspicuous, if not the most essential, parts of moral approbation and disapprobation.

But to rise to a more general consideration: Perception and emotion are states of mind perfectly distinct; and an emotion of pleasure or pain differs much more from a mere perception, than the perceptions of one sense do from those of another. The perceptions of all the senses have some qualities in common. But an emotion has not necessarily anything in common with a perception, but that they are both states of mind. We perceive exactly the same qualities in coffee when we may dislike it, as afterwards when we come to like it. In other words, the perception remains the same when the sensation of pain is changed into the opposite sensation of pleasure. The like change may occur in every case where pleasure or pain (in such instances called sensations) enter the mind with perceptions through the eye or the ear. The prospect or the sound which was disagreeable may become agreeable, without any alteration in our idea of the objects. We can easily imagine a percipient and thinking being without a capacity of receiving pleasure or pain. Such a being might perceive what we do; if we could conceive him to reason, he might reason justly; and if he were to judge at all, there seems no reason why he should not judge truly. But what could induce such a being to *will* or to *act?* It seems evident that his existence could only be a state of passive contemplation. Reason, as reason, can never be a motive to action. It is only when we superadd to such a being sensibility, or the capacity of emotion or sentiment, (or what in corporeal cases is called sensation) of desire and aversion, that we introduce him into the world of action. We then clearly discern, that when the conclusion of a process of reasoning presents to his mind an object of desire, or the means of obtaining it, a motive of action begins to operate; and reason may then, but not till then, have a powerful though indirect influence on conduct. Let any argument to dissuade a man from immorality be employed, and the issue of it will always appear to be an appeal to a feeling. You prove that drunkenness will probably ruin health. No position founded on experience is more certain. Most persons with whom you reason must be as much convinced of it as you are. But your hope of success depends on the drunkard's fear of ill health; and he may always silence your argument by telling you that he loves wine more than he dreads sickness. You speak in vain of the infamy of an act to one who disregards the opinion of others; or of its imprudence to a man of little feeling for his own future condition. You may truly, but vainly, tell of the pleasures of friendship to one who has little affection. If you display the delights of liberality to a miser, he may always shut your mouth by answering, "The spendthrift may prefer such pleasures; I love money more." If you even appeal to a man's conscience, he may answer you, that you have clearly proved the immorality of the act, and that he himself knew it before; but that now when you had renewed and freshened his conviction, he was obliged to own, that his love of virtue, even aided by the fear of dishonour, remorse, and punishment, was not so powerful as the desire which hurried him into vice.

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[1] *Evidence of Natural and Revealed Religion*, p. 4.

Nor is it otherwise, however confusion of ideas may cause it to be so deemed, with that calm regard to the welfare of the agent, to which philosophers have so grossly misapplied the hardly intelligible appellation of self-love. The general tendency of right conduct to permanent wellbeing is indeed one of the most evident of all truths. But the success of persuasives or dissuasives addressed to it, must always be directly proportioned, not to the clearness with which the truth is discerned, but to the strength of the principle addressed, in the mind of the individual; and to the degree in which he is accustomed to keep an eye on its dictates. A strange prejudice prevails, which ascribes to what is called *self-love* an invariable superiority over all the other motives of human action. If it were to be called by a more fit name, such as foresight, prudence, or, what seems most exactly to describe its nature, a sympathy with the future feelings of the agent, it would appear to every observer to be, very often, too languid and inactive, always of late appearance, and, sometimes, so faint as to be scarcely perceptible. Almost every human passion in its turn prevails over self-love.

It is thus apparent that the influence of reason on the will is indirect, and arises only from its being one of the channels by which the objects of desire or aversion are brought near to these springs of voluntary action. It is only one of these channels. There are many other modes of presenting to the mind the proper objects of the emotions which it is intended to excite, whether of a calmer or of a more active nature; so that they may influence conduct more powerfully than when they reach the will through the channel of conviction. The distinction between conviction and persuasion would indeed be otherwise without a meaning: to teach the mind would be the same thing as to move it; and eloquence would be nothing but logic, although the greater part of the power of the former is displayed in the direct excitement of feeling;—on condition, indeed, (for reasons foreign to our present purpose) that the orator shall never appear to give counsel inconsistent with the duty or the lasting welfare of those whom he would persuade. In like manner it is to be observed, that though reasoning be one of the instruments of education, yet education is not a proof of reasoning, but a wise disposal of all the circumstances which influence character, and of the means of producing those habitual dispositions which insure well-doing, of which reasoning is but one. Very similar observations are applicable to the great arts of legislation and government; which are here only alluded to as forming a strong illustration of the present argument.

The abusive extension of the term *Reason* to the moral faculties, one of the predominant errors of ancient and modern times, has arisen from causes which it is not difficult to discover. Reason does in truth perform a great part in every case of moral sentiment. To reason often belong the preliminaries of the act; to reason altogether belongs the choice of the means of execution. The operations of reason, in both cases, are comparatively slow and lasting; they are capable of being distinctly recalled by memory. The emotion which intervenes between the previous and the succeeding exertions of reason is often faint, generally transient, and scarcely ever capable of being reproduced by an effort of the mind. Hence the name of reason is applied to this mixed state of mind; more especially when the feeling, being of a cold and general nature, and scarcely ruffling the surface of the soul, such as those of prudence and of ordinary kindness and propriety, almost passes unnoticed, and is irretrievably forgotten. Hence the mind is, in such conditions, said by moralists to act from *reason*, in contradistinction to its more excited and disturbed state, when it is said to act from *passion*. The calmness of reason gives to the whole compound the appearance of unmixed reason. The illusion is further promoted by a mode of expression used in most languages. A man is said to act reasonably, when his conduct is such as may be reasonably expected. Amidst the disorders of a vicious mind, it is difficult to form a reasonable conjecture concerning future conduct; but the quiet and well-ordered state of virtue renders the probable acts of her fortunate votaries the object of very rational expectation.

As far as it is not presumptuous to attempt a distinction between modes of thinking foreign to the mind which makes the attempt, and modes of expression scarcely translatable into the only technical language in which that mind is wont to think, it seems that the systems of Cudworth and Clarke, though they appear very similar, are in reality different in some important points of view. The former, a Platonist, sets out from those Ideas, (a word, in this acceptation of it, which has no corresponding term in English) the eternal models of created things, which, as the Athenian master taught, pre-existed in the everlasting intellect, and, of right, rule the will of every inferior mind. The illustrious scholar of Newton, with a manner of thinking more natural to his age and school, considered primarily the very relations of things themselves; conceived indeed by the Eternal Mind, but which, if such inadequate language may be pardoned, are the law of its will, as well as the model of its works.[1]

EARL OF SHAFTESBURY.[2]

Lord Shaftesbury, the author of the *Characteristics*, was the grandson of Sir Antony Ashley Cooper, created Earl of Shaftesbury, one of the master spirits of the English nation, whose vices, the bitter fruits of the insecurity of a troublous time, succeeded by the corrupting habits of an inconstant, venal, and profligate court, have led an ungrateful posterity to overlook his wisdom, and disinterested perseverance, in obtaining for the English nation the unspeakable benefits of the Habeas Corpus act. The fortune of the *Characteristics* has been singular. For a time the work was admired more undistinguishingly than its literary character warrants. In the succeeding period it was justly criticised, but too severely condemned. Of late, more unjustly than in either of the former cases, it has been generally neglected. It seemed to have the power of changing the temper of its critics. It provoked the amiable Berkeley to a harshness equally unwonted and unwarranted;[1] while it softened the rugged Warburton so far as to dispose the fierce yet not altogether ungenerous polemic to praise an enemy in the very heat of conflict.[2]

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[1] Mr Wollaston's system, that morality consisted in acting according to truth, seems to coincide with that of Dr Clarke. The murder of Cicero by Popilius Lenas, was, according to him, a practical falsehood; for Cicero had been his benefactor, but Popilius acted as if that were untrue. If the truth spoken of be, that gratitude is due for benefits, the reasoning is evidently a circle. If *any truth* be meant, indifferently, it is plain that the assassin acted in perfect conformity to several certain truths; such as the malignity of Antony, the ingratitude and venality of Popilius, and the probable impunity of his crime, when law was suspended, and good men without power.

[2] Born in 1671; died in 1713.

Leibnitz, the most celebrated of Continental philosophers, warmly applauded the *Characteristics*, and, (what was a more certain proof of admiration) though at an advanced age, criticised that work minutely.[3] Le Clerc, who had assisted the studies of the author, contributed to spread its reputation by his *Journal*, then the most popular in Europe. Locke is said to have aided in his education, probably rather by counsel than by tuition. The author had indeed been driven from the regular studies of his country by the insults with which he was loaded at Winchester school, when he was only twelve years old, immediately after the death of his grandfather; a choice of time which seemed not so much to indicate anger against the faults of a great man, as triumph over the principles of liberty, which seemed at that time to have fallen for ever. He gave a genuine proof of respect for freedom of thought, by preventing the expulsion, from Holland, of Bayle, (with whom he differs in every moral, political, and, it may be truly added, religious opinion) when, it must be owned, the right of asylum was, in strict justice, forfeited by the secret services which the philosopher had rendered to the enemy of Holland and of Europe. In the small part of his short life which premature infirmities allowed him to apply to public affairs, he co-operated zealously with the friends of freedom; but, as became a moral philosopher, he supported, even against them, a law to allow those who were accused of treason to make their defence by counsel, although the parties first to benefit from this act of imperfect justice were conspirators to assassinate King William, and to re-enslave their country. On that occasion it is well known with what admirable quickness he took advantage of the embarrassment which seized him, when he rose to address the House of Commons. "If I," said he, "who rise only to give my opinion on this bill, am so confounded that I cannot say what I intended, what must the condition of that man be, who, without assistance, is pleading for his own life!" He was the friend of Lord Somers; and the tribute paid to his personal character by Warburton, who knew many of his contemporaries and some of his friends, may be considered as evidence of its excellence.

His fine genius and generous spirit shine through his writings; but their lustre is often dimmed by peculiarities, and, it must be said, by affectations, which, originating in local, temporary, or even personal circumstances, are particularly fatal to the permanence of fame. There is often a charm in the egotism of an artless writer, or of an actor in great scenes. But other laws are imposed on the literary artist. Lord Shaftesbury, instead of hiding himself behind his work, stands forward with too frequent marks of self-complacency, as a nobleman of polished manners, with a mind adorned by the fine arts, and instructed by ancient philosophy; shrinking with a somewhat effeminate fastidiousness from the clamour and prejudices of the multitude, whom he neither deigns to conciliate nor puts forth his strength to subdue. The enmity of the majority of churchmen to the government established at the Revolution, was calculated to fill his mind with angry feelings; which overflow too often, if not upon Christianity itself, yet upon representations of it, closely intertwined with those religious feelings to which, in other forms, his own philosophy ascribes surpassing worth. His small, and occasional writings, of which the main fault is the want of an object or a plan, have many passages remarkable for the utmost beauty and harmony of language. Had he imbibed the simplicity, as well as copied the expression and cadence of the greater ancients, he would have done more justice to his genius; and his works, like theirs, would have been preserved by that quality, without which but a very few writings, of whatever mental power, have long survived their writers. Grace belongs only to natural movements; and Lord Shaftesbury, notwithstanding the frequent beauty of his thoughts and language, has rarely attained it. He is unfortunately prone to pleasantry, which is obstinately averse from constraint, and which he had no interest in raising to be the test of truth. His affectation of liveliness as a man of the world, tempts him sometimes to overstep the indistinct boundaries which separate familiarity from vulgarity. Of his two more considerable writings, the *Moralists*, on which he evidently most valued himself, and which is spoken of by Leibnitz with enthusiasm, is by no means the happiest. Yet perhaps there is scarcely any composition in our language more lofty in its moral and religious sentiments, and more exquisitely elegant and musical in its diction, than the Platonic representation of the scale of beauty and love, in the speech to Palemon, near the close of the first part.[1] Many passages might be quoted, which in some measure justify the enthusiasm of the septuagenarian geometer. Yet it is not to be concealed that, as a whole, it is heavy and languid. It is a modern antique. The dialogues of Plato are often very lively representations of conversations which might take place daily at a great university, full, like Athens, of rival professors and eager disciples,—between men of various character, and great fame as well as ability. Socrates runs through them all. His great abilities, his still more venerable virtues, his cruel fate, especially when joined to his very characteristic peculiarities,—to his grave humour, to his homely sense, to his assumed humility, to the honest sliness with which he ensnared the Sophists, and to the intrepidity with which he dragged them to justice, gave unity and dramatic interest to these dialogues as a whole. But Lord Shaftesbury's dialogue is between fictitious personages, and in a tone at utter variance with English conversation. He had great power of thought and command over words. But he had no talent for inventing character and bestowing life on it. The *Inquiry concerning Virtue*[2] is nearly exempt from the faulty peculiarities of the author; the method is perfect, the reasoning just, the style precise and clear. The writer has no purpose but that of honestly proving his principles; he himself altogether disappears; and he is intent only on earnestly enforcing what he truly, conscientiously, and reasonably believes. Hence the charm of simplicity is revived in this production, which is unquestionably entitled to a place in the first rank of English tracts on Moral Philosophy.

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[1] BERKELEY's *Minute Philosopher*, Dialogue iii.; but especially his *Theory of Vision Vindicated*, Lond. 1733, (not republished in the quarto edition of his works) where this most excellent man sinks for a moment to the level of a railing polemic.

[2] It is remarkable that the most impure passages of Warburton's composition are those in which he lets loose his controversial zeal, and that he is a fine writer principally where he writes from generous feeling. "Of all the virtues which were so much in this noble writer's heart and in his writings, there was not one he more revered than the love of public liberty. ...The noble author of the *Characteristics* had many excellent qualities, both as a man and a writer. He was temperate, chaste, honest, and a lover of his country. In his writings he has shown how much he has imbibed the deep sense, and how naturally he could copy the gracious manner, of Plato." (Dedication to the Freethinkers, prefixed to the *Divine Legation.*) Warburton, however, soon relapses, but not without excuse; for he thought himself vindicating the memory of Locke.

[3] *Opera*, tom. III. p. 39–56.

The point in which it becomes especially pertinent to the subject of this Dissertation is, that it contains more intimations of an original and important nature on the Theory of Ethics than perhaps any preceding work of modern times.[3] It is true that they are often but intimations, cursory, and appearing almost to be casual; so that many of them have escaped the notice of most readers, and even writers on these subjects.

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[1] *Characteristics*, Treatise v. *The Moralists*, Part i. sect. 3.

[2] *Ibid.* Treatise iv.

[3] I am not without suspicion that I have overlooked the claims of Dr Henry More, who, notwithstanding some uncouthness of language, seems to have given the first intimations of a distinct moral faculty, which he calls "the Boniform Faculty;" a phrase against which an outcry would now be raised as German. Happiness, according to him, consists in a constant satisfaction, εν τῳ αγαθοειδει της ψυχης. (*Enchiridion Ethicum*, lib. i. cap. ii.)

That the consequences of some of them are even yet not unfolded, must be owned to be a proof that they are inadequately stated; and may be regarded as a presumption that the author did not closely examine the bearings of his own positions. Among the most important of these suggestions is, the existence of dispositions in man, by which he takes pleasure in the wellbeing of others, without any further view; a doctrine, however, to all the consequences of which he has not been faithful in his other writings.[1] Another is, that goodness consists in the prevalence of love for the system of which we are a part, over the passions, pointing to our individual welfare; a proposition which somewhat confounds the motives of right acts with their tendency, and seems to favour the melting of all particular affections into general benevolence, because the tendency of these affections is to general good. The next, and certainly the most original, as well as important, is, that there are certain affections of the mind which, being contemplated by the mind itself through what he calls *a reflex sense*, become the objects of love, or the contrary, according to their nature. So approved and loved, they constitute *virtue* or *merit*, as distinguished from mere *goodness*, of which there are traces in animals who do not appear to *reflect* on the state of their own minds, and who seem, therefore, destitute of what he elsewhere calls *a moral sense.* These statements are, it is true, far too short and vague. He nowhere inquires into the origin of the reflex sense. What is a much more material defect, he makes no attempt to ascertain in what state of mind it consists. We discover only by implication, and by the use of the term *sense*, that he searches for the fountain of moral sentiments, not in mere reason, where Cudworth and Clarke had vainly sought for it, but in the heart, whence the main branch of them assuredly flows. It should never be forgotten, that we owe to these hints the reception, into ethical theory, of a moral sense; which, whatever may be thought of its origin, or in whatever words it may be described, must always retain its place in such theory as a main principle of our moral nature.

His demonstration of the utility of virtue to the individual, far surpasses all attempts of the same nature; being founded, not on a calculation of outward advantages or inconveniences, alike uncertain, precarious, and degrading, but on the unshaken foundation of the delight, which is of the very essence of social affection and virtuous sentiment; on the dreadful agony inflicted by all malevolent passions, upon every soul that harbours the hellish inmates; on the all-important truth, that to love is to be happy, and to hate is to be miserable,—that affection is its own reward, and ill-will its own punishment; or, as it has been more simply and more affectingly, as well as with more sacred authority, taught, that to give is more blessed than to receive, and that to love one another is the sum of all human virtue.

The relation of religion to morality, as far as it can be discovered by human reason, was never more justly or more beautifully stated.[2] If he represented the mere hope of reward and dread of punishment as selfish, and therefore inferior motives to virtue and piety, he distinctly owns their efficacy in reclaiming from vice, in rousing from lethargy, and in guarding a feeble penitence; in all which he coincides with illustrious and zealous Christian writers. "If by the hope of reward be understood the love and desire of virtuous enjoyment, or of the very practice and exercise of virtue in another life; an expectation or hope of this kind is so far from being derogatory from virtue, that it is an evidence of our loving it the more sincerely and *for its own sake.*"[3]

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[1] "It is the height of wisdom no doubt to be rightly selfish." (*Charac.* I. 121.) The observation seems to be taken from what Aristotle says of Φιλαυτια: Τον μεν αγαϑον δει φιλαυτον ειναι. (ARIST. *Ethic.* ix. c. viii.) The chapter is admirable, and the assertion of Aristotle is very capable of a good sense.

[2] *Characteristics, Inquiry concerning Virtue.*

[3] *Ibid.*

So Jeremy Taylor: "He that is grown in grace pursues virtue purely and simply for its own interest. When persons come to that height of grace, and love God for himself, that is but heaven in another sense." (*Sermon on Growth in Grace.*) So before him the once celebrated Mr John Smith of Cambridge: "The happiness which good men shall partake is not distinct from their godlike nature. Happiness and holiness are but two several notions of one thing. Hell is rather a

FENELON[1]—BOSSUET.[2]

As the last question, though strictly speaking theological, is yet in truth dependent on the more general question, which relates to the reality of disinterested affections in human nature, it seems not foreign from the present purpose to give a short account of a dispute on the subject in France, between two of the most eminent persons of their time; namely, the controversy between Fenelon and Bossuet, concerning the possibility of men being influenced by the pure and disinterested love of God. Never were two great men more unlike. Fenelon in his writings exhibits more of the qualities which predispose to religious feelings, than any other equally conspicuous person;—a mind so pure as steadily to contemplate supreme excellence; a heart capable of being touched and affected by the contemplation; a gentle and modest spirit, not elated by the privilege, but seeing its own want of worth as it came nearer to such brightness, and disposed to treat with compassionate forbearance those errors in others, of which it felt a humbling consciousness. Bossuet was rather a great minister in the ecclesiastical commonwealth; employing knowledge, eloquence, argument, the energy of his character, the influence, and even the authority of his station, to vanquish opponents, to extirpate revolters, and, sometimes with a patrician firmness, to withstand the dictatorial encroachment of the Roman Pontiff on the spiritual aristocracy of France. Fenelon had been appointed tutor to the Duke of Burgundy. He had all the qualities which fit a man to be the preceptor of a prince, and which most disable him to get or to keep the office. Even birth, and urbanity, and accomplishment, and vivacity, were an insufficient atonement for his genius and virtue. Louis XIV. distrusted so fine a spirit, and appears to have early suspected, that a fancy moved by such benevolence might imagine examples for his grandson which the world would consider as a satire on his own reign. Madame de Maintenon, indeed, favoured him; but he was generally believed to have forfeited her good graces by discouraging her projects for at least a nearer approach to a seat on the throne. He offended her by obeying her commands, in laying before her an account of her faults, and some of those of her royal husband, which was probably the more painfully felt for its mildness, justice, and refined observation.[3] An opportunity for driving such an intruder from a court presented itself somewhat strangely, in the form of a subtile controversy on one of the most abstruse questions of metaphysical theology. Molinos, a Spanish priest, reviving and perhaps exaggerating the maxims of the ancient Mystics, had recently taught, that Christian perfection consisted in the pure love of God, without hope of reward or fear of punishment. This offence he expiated by seven years' imprisonment in the dungeons of the Roman Inquisition. His opinions were embraced by Madame Guyon, a pious French lady of strong feeling and active imagination, who appears to have expressed them in a hyperbolical language, not infrequent in devotional exercises, especially in those of otherwise amiable

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nature than a place, and heaven cannot be so well defined by anything *without* us, as by something within us." (*Select Discourses*, 2d edit. Cambridge, 1673.)

In accordance with these old authorities is the recent language of a most ingenious as well as benevolent and pious writer. "The *holiness* of heaven is still more attractive to the Christian than its happiness. The desire of doing that which is right for its own sake is a part of his desire after heaven." (*Unconditional Freeness of the Gospel*, by T. Erskine, Esq. p. 32, 33. Edinb. 1828.)

See also the Appendix to Ward's *Life of Henry More*, 247–271. This account of that ingenious and amiable philosopher (Lond. 1710) contains an interesting view of his opinions, and many beautiful passages of his writings, but unfortunately very few particulars of the man. His letters on *Disinterested Piety*, (see the Appendix to Mr Ward's work) his boundless charity, his zeal for the utmost toleration, and his hope of general improvement from "a pacific and perspicacious posterity," place him high in the small number of true philosophers who, in their estimate of men, value dispositions more than opinions, and in their search for good, more often look forward than backward.

[1] Born in 1651; died in 1715.

[2] Born in 1627; died in 1704.

[3] Bausset, *Histoire de Fénelon*, I. 252.

persons of her sex and character. In the fervour of her zeal, she disregarded the usages of the world and the decorums imposed on females. She left her family, took a part in public conferences, and assumed an independence scarcely reconcilable with the more ordinary and more pleasing virtues of women. Her pious effusions were examined with the rigour which might be exercised on theological propositions. She was falsely charged by Harlay, the dissolute archbishop of Paris, with personal licentiousness. For these crimes she was dragged from convent to convent, imprisoned for years in the Bastile, and, as an act of mercy, confined during the latter years of her life to a provincial town, as a prison at large. A piety thus pure and disinterested could not fail to please Fenelon. He published a work in justification of Madame Guyon's character, and in explanation of the degree in which he agreed with her. Bossuet, the oracle and champion of the church, took up arms against him. It would be painful to suppose that a man of so great powers was actuated by mean jealousy, and it is needless. The union of zeal for opinion with the pride of authority, is apt to give sternness to the administration of controversial bishops; to say nothing of the haughty and inflexible character of Bossuet himself. He could not brook the independence of him who was hitherto so docile a scholar and so gentle a friend. He was jealous of novelties, and dreaded a fervour of piety likely to be ungovernable, and perhaps to excite movements of which no man could foresee the issue. It must be allowed that he had reason to be displeased with the indiscretion and turbulence of the innovators, and might apprehend that, in preaching motives to virtue and religion which he thought unattainable, the coarser but surer foundations of common morality might be loosened. A controversy ensued, in which he employed the utmost violence of polemical or factious contest. Fenelon replied with brilliant success, and submitted his book to the judgment of Rome. After a long examination, the commission of ten Cardinals appointed to examine it were equally divided, and he seemed in consequence about to be acquitted. But Bossuet had in the mean time easily gained Louis XIV. Madame de Maintenon betrayed Fenelon's confidential correspondence; and he was banished to his diocese, and deprived of his pensions and official apartments in the palace. Louis XIV. regarded the slightest differences from the authorities of the French church as rebellion against himself. Though endowed with much natural good sense, he was too grossly ignorant to be made to comprehend one of the terms of the question in dispute. He did not, however, scruple to urge the Pope to the condemnation of Fenelon. Innocent XII. (Pignatelli) an aged and pacific Pontiff, was desirous of avoiding such harsh measures. He said that "the archbishop of Cambray might have erred from excess in the love of God, but the bishop of Meaux had sinned by a defect of the love of his neighbour."[1] But he was compelled to condemn a series of propositions, of which the first was, "there is an habitual state of love to God, which is pure from every motive of personal interest, and in which neither the fear of punishment nor the hope of reward has any part."[2] Fenelon read the bull which condemned him in his own cathedral, and professed as humble a submission as the lowest of his flock. In some of the writings of his advanced years, which have been recently published, we observe with regret that, when wearied out by his exile, ambitious to regain a place at court through the Jesuits, or prejudiced against the Calvinising doctrines of the Jansenists, the strongest anti-papal party among Catholics, or somewhat detached from a cause of which his great antagonist had been the victorious leader, he made concessions to the absolute monarchy of Rome, which did not become a luminary of the Gallican church.[3]

Bossuet, in his writings on this occasion, besides tradition and authorities, relied mainly on the supposed principle of philosophy, that man must desire his own happiness, and cannot desire anything else, otherwise than as a means towards it; which renders the controversy an incident in the history of Ethics. It is immediately connected with the preceding part of this Dissertation, by the almost literal coincidence between Bossuet's foremost objection to the disinterested piety contended for by Fenelon, and the fundamental position of a very ingenious and once noted divine of the English church, in his attack on the disinterested affections, believed by Shaftesbury to be a part of human nature.[1]

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[1] Bausset, *Histoire de Fénelon*, II. 220, note.

[2] *Œuvres de* Bossuet, VIII. 308. Liege, 1767, 8vo.

[3] *De Summi Pontificis Auctoritate Dissertatio: Œuvres de* Fenelon, tome II. Versailles, 1820.

LEIBNITZ.[2]

There is a singular contrast between the form of Leibnitz's writings and the character of his mind. The latter was systematical, even to excess. It was the vice of his prodigious intellect, on every subject of science where it was not bound by geometrical chains, to confine his view to those most general principles, so well called by Bacon "merely notional;" which render it, indeed, easy to build a system, but, only because they may be alike adapted to every state of appearances, and become thereby really inapplicable to any. Though his genius was thus naturally turned to system, his writings were, generally, occasional and miscellaneous. The fragments of his doctrines are scattered in Reviews; or over a voluminous Literary Correspondence; or in the Prefaces and Introductions to those compilations to which this great philosopher was obliged by his situation to descend. This defective and disorderly mode of publication arose partly from the jars between business and study, inevitable in his course of life; but probably yet more from the nature of his system, which, while it widely deviates from the most general principles of former philosophers, is ready to embrace their particular doctrines under its own generalities, and thus to reconcile them to each other, as well as to accommodate itself to popular or established opinions, and compromise with them, according to his favourite and oft-repeated maxim, "*that most received doctrines are capable of a good sense*;"[3] by which last words our philosopher meant a sense reconcilable with his own principles. Partial and occasional exhibitions of these principles suited better that constant negotiation with opinions, establishments, and prejudices, to which extreme generalities are well adapted, than a full and methodical statement of the whole at once. It is the lot of every philosopher who attempts to make his principles extremely flexible, that they become like those tools which bend so easily as to penetrate nothing. Yet his manner of publication perhaps led him to those wide intuitions, as comprehensive as those of Bacon, of which he expressed the result as briefly and pithily as Hobbes. The fragment which contains his ethical principles is the Preface to a collection of documents illustrative of international law, published at Hanover in 1693;[4] to which he often referred as his standard afterwards, especially when he speaks of Lord Shaftesbury, or of the controversy between the two great theologians of France. "Right," says he, "is moral power; obligation moral necessity. By *moral*, I understand what with a good man prevails as much as if it were physical. A good man is he who loves all men as far as reason allows. Justice is the benevolence of a wise man. *To love is to be pleased with the happiness of another; or, in other words, to convert the happiness of another into a part of one's own.* Hence is explained the possibility of a disinterested love. When we are pleased with the happiness of any being, his happiness becomes one of our enjoyments. Wisdom is the science of happiness."[1]

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[1] "Hæc est natura voluntatis humanæ, ut et beatitudinem, et ea quorum necessaria connexio cum beatitudine clare intelligitur, *necessario* appetat... ..Nullus est actus ad quem revera non impellimur motivo beatitudinis, explicite vel *implicite*;" meaning by the latter that it may be concealed from ourselves, as he says, *for a short time*, by a nearer object. (*Œuvres de* Bossuet, VIII. 80.) "The only motive by which individuals *can* be induced to the practice of virtue, *must* be the feeling or the prospect of private happiness." (Brown's *Essays on the Characteristics*, p. 159. Lond. 1752.) It must, however, be owned, that the selfishness of the Warburtonian is more rigid; making no provision for the object of one's own happiness slipping out of view for a moment. It is due to the very ingenious author of this forgotten book to add, that it is full of praise of his adversary, which, though just, was in the answerer generous; and that it contains an assertion of the *unbounded* right of public discussion, unusual even at the tolerant period of its appearance.

[2] Born in 1646; died in 1716.

[3] *Nouveaux Essais sur l'Entendement Humain*, liv. i. chap. ii. p. 57. These Essays, which form the greater part of the publication entitled *Œuvres Philosophiques*, edited by Raspe, Amst. et Leipz. 1765, are not included in Dutens's edition of Leibnitz's works.

[4] *Codex Juris Gentium Diplomaticus.* Hanov. 1695.

REMARKS.

It is apparent from the above passage, that Leibnitz had touched the truth on the subject of disinterested affection; and that he was more near clinging to it than any modern philosopher, except Lord Shaftesbury. It is evident, however, from the latter part of it, that, like Shaftesbury, he shrunk from his own just conception; under the influence of that most ancient and far-spread prejudice of the schools, which assumed that such an abstraction as *Happiness* could be the object of love, and that the desire of so faint, distant, and refined an object, was the first principle of all moral nature, of which every other desire was only a modification or a fruit. Both he and Shaftesbury, however, when they relapsed into the selfish system, embraced it in its most refined form; considering the benevolent affections as valuable parts of our own happiness, not in consequence of any of their effects or extrinsic advantages, but of that intrinsic delightfulness which was inherent in their very essence. But Leibnitz considered this refined pleasure as the object in the view of the benevolent man; an absurdity, or rather a contradiction, which, at least in the *Inquiry concerning Virtue*, Shaftesbury avoids. It will be seen from Leibnitz's limitation, taken together with his definition of Wisdom, that he regarded the distinction of the moral sentiments from the social affections, and the just subordination of the latter, as entirely founded on the tendency of general happiness to increase that of the agent, not merely as being real, but as being present to the agent's mind when he acts. In a subsequent passage he lowers his tone not a little. ' As for the sacrifice of life, or the endurance of the greatest pain for others, these things are rather generously enjoined than solidly demonstrated by philosophers. For honour, glory, and self-congratulation, to which they appeal under the name of Virtue, are indeed mental pleasures, and of a high degree, but not to all, nor outweighing every bitterness of suffering; since all cannot imagine them with equal vivacity, and that power is little possessed by those whom neither education, nor situation, nor the doctrines of religion or philosophy, have taught to value mental gratifications."[2] He concludes very truly, that morality is completed by a belief of moral government. But the *Inquiry concerning Virtue* had reached that conclusion by a better road. It entirely escaped his sagacity, as it has that of nearly all other moralists, that the coincidence of morality with well-understood interest in our outward actions, is very far from being the most important part of the question; for these actions flow from habitual dispositions, from affections and sensibilities, which determine their nature. There may be, and there are many immoral acts, which, in the sense in which words are commonly used, are advantageous to the actor. But the whole sagacity and ingenuity of the world may be safely challenged to point out a case in which virtuous dispositions, habits, and feelings, are not conducive in the highest degree to the happiness of the individual; or to maintain that he is not the happiest, whose moral sentiments and affections are such as to prevent the possibility of the prospect of advantage through unlawful means from presenting itself to his mind. It would indeed have been impossible to prove to Regulus that it was his interest to return to a death of torture in Africa. But what if the proof had been easy? The most thorough conviction on such a point would not have enabled him to set this example, if he had not been supported by his own integrity and generosity, by love of his country, and reverence for his pledged faith. What could the conviction add to that greatness of soul, and to these glorious attributes? With such virtues he could not act otherwise than he did. Would a father affectionately interested in a son's happiness, of very lukewarm feelings of morality, but of good sense enough to weigh gratifications and sufferings exactly, be really desirous that his son should have these virtues in a less degree than Regulus, merely because they might expose him to the fate which Regulus chose? On the coldest calculation he would surely perceive, that the high and glowing feelings of such a mind during life, altogether throw into shade a few hours of agony in leaving it. And, if he himself were so unfortunate that no more generous sentiment arose in his mind to silence such calculations, would it not be a reproach to his understanding not to discover, that though in one case out of millions such a character might lead a Regulus to torture, yet, in the common course of nature, it is the source not only of happiness in life, but of quiet and honour in death. A case so extreme as that of Regulus will not perplex, if we bear in mind, that though we cannot prove the *act* of heroic virtue to be conducive to the interest of the hero, yet we may perceive at once, that nothing is so conducive to his interest as to have a mind so formed that it could not shrink from it, but must rather embrace it with gladness and triumph. Men of vigorous health are said sometimes to suffer most in a pestilence. No man was ever so absurd as for that reason to wish that he were more infirm. The distemper might return once in a century. If he were then alive, he might escape it; and even if he fell, the balance of advantage would be in most cases greatly on the side of robust health. In estimating beforehand the value of a strong bodily frame, a man of sense would throw the small chance of a rare and short evil entirely out of the account. So must the coldest and most selfish moral calculator, who, if he be sagacious and exact, must pronounce, that the inconveniences to which a man may be sometimes exposed by a pure and sound mind, are no reasons for regretting that we do not escape them by possessing minds more enfeebled and distempered. Other occasions will call our attention, in the sequel, to this important part of the subject. But the great name of Leibnitz seemed to require that his degrading statement should not be cited without warning the reader against its egregious fallacy.

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[1] See Notes and Illustrations, note N.

[2] *Ibid.* note N.

MALEBRANCHE.[1]

This ingenious philosopher and beautiful writer is the only celebrated Cartesian who has professedly handled the Theory of Morals.[2] His theory has in some points of view a conformity to the doctrine of Clarke; while in others it has given occasion to his English follower Norris[3] to say, that if the Quakers understood their own opinion of the illumination of all men, they would explain it on the principles of Malebranche. "There is," says he, "one parent virtue, the universal virtue, the virtue which renders us just and perfect, the virtue which will one day render us happy. It is the only virtue. It is the love of the universal order, as it eternally existed in the Divine reason, where every created reason contemplates it. This order is composed of practical as well as speculative truth. Reason perceives the moral superiority of one being over another, as immediately as the equality of the radii of the same circle. The relative perfection of beings is that part of the immovable order to which men must conform their minds and their conduct. The love of order is the whole of virtue, and conformity to order constitutes the morality of actions." It is not difficult to discover, that in spite of the singular skill employed in weaving this web, it answers no other purpose than that of hiding the whole difficulty. The love of universal order, says Malebranche, requires that we should value an animal more than a stone, because it is more valuable; and love God infinitely more than man, because he is infinitely better. But without *presupposing* the reality of moral distinctions, and the power of moral feelings, the two points to be proved, how can either of these propositions be evident, or even intelligible? To say that a love of the eternal order will produce the love and practice of every virtue, is an assertion untenable unless we take morality for granted, and useless if we do.

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[1] Born in 1638; died in 1715.

[2] *Traité de Morale.* Rotterdam, 1684.

[3] Author of the *Theory of the Ideal World*, who well copied, though he did not equal the clearness and choice of expression which belonged to his master.

In his work on Morals, all the incidental and secondary remarks are equally well considered and well expressed. The manner in which he applied his principle to the particulars of human duty, is excellent. He is perhaps the first philosopher who has precisely laid down and rigidly adhered to the great principle, *that virtue consists in pure intentions and dispositions of mind*, without which, actions, however conformable to rules, are not truly moral; a truth of the highest importance, which, in the theological form, may be said to have been the main principle of the first Protestant Reformers. The ground of piety, according to him, is the conformity of the attributes of God to those moral qualities which we irresistibly love and revere.[1] " Sovereign princes," says he, " have no right to use their authority without reason. Even God has no such miserable right."[2] His distinction between a religious society and an established church, and his assertion of the right of the temporal power alone to employ coercion, are worthy of notice, as instances in which a Catholic, at once philosophical and orthodox, could thus speak, not only of the nature of God, but of the rights of the church.

JONATHAN EDWARDS.[3]

THIS remarkable man, the metaphysician of America, was formed among the Calvinists of New England, when their stern doctrine retained its rigorous authority.[4] His power of subtile argument, perhaps unmatched, certainly unsurpassed among men, was joined, as in some of the ancient Mystics, with a character which raised his piety to fervour. He embraced their doctrine, probably without knowing it to be theirs. " True religion," says he, " in a great measure consists in holy affections. A love of divine things, for the beauty and sweetness of their moral excellency, is the spring of all holy affections."[5] Had he suffered this noble principle to take the right road to all its fair consequences, he would have entirely concurred with Plato, with Shaftesbury, and Malebranche, in devotion to " the first good, first perfect, and first fair." But he thought it necessary afterwards to limit his doctrine to his own persuasion, by denying that such moral excellence could be discovered in divine things by those Christians who did not take the same view with him of their religion. All others, and some who hold his doctrines with a more enlarged spirit, may adopt his principle without any limitation. His ethical theory is contained in his *Dissertation on the Nature of True Virtue;* and in another, *On God's Chief End in the Creation*, published in London thirty years after his death. True virtue, according to him, consists in benevolence, or love to being " in general," which he afterwards limits to " intelligent being," though *sentient* would have involved a more reasonable limitation. This good-will is felt towards a particular being, first *in proportion to his degree of existence* (for, says he, " that which is great has more existence, and is farther from nothing, than that which is little"); and secondly, *in proportion to the degree in which that particular being feels benevolence to others.* Thus God, having infinitely more existence and benevolence than man, ought to be infinitely more loved; and for the same reason, God must love himself infinitely more than he does all other beings.[1] He can act only from regard to himself, and his end in creation can only be to manifest his whole nature, which is called acting for his own glory.

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[1] " Il faut aimer l'Etre infiniment parfait, et non pas un fantôme épouvantable, un Dieu injuste, absolu, puissant, mais sans bonté et sans sagesse. S'il y avoit un tel Dieu, le vrai Dieu nous défendroit de l'adorer et de l'aimer. Il y a peut-être plus de danger d'offenser Dieu lorsqu'on lui donne une forme si horrible, que de mépriser ce fantôme." (*Traité de Morale*, chap. viii.)

[2] *Ibid.* chap. xxii.

[3] Born in 1703, at Windsor in Connecticut; died in 1758, at Princeton in New Jersey.

[4] Notes and Illustrations, note O.

[5] EDWARDS *on Religious Affections*, p. 4, 187. Lond. 1796.

As far as Edwards confines himself to created beings, and while his theory is perfectly intelligible, it coincides with that of universal benevolence, hereafter to be considered. The term *being* is a mere encumbrance, which serves indeed to give it a mysterious outside, but brings with it from the schools nothing except their obscurity. He was betrayed into it by the cloak which it threw over his really unmeaning assertion or assumption, that there are *degrees of existence;* without which that part of his system which relates to the Deity would have appeared to be as baseless as it really is. When we try such a phrase by applying it to matters within the sphere of our experience, we see that it means nothing but *degrees* of certain faculties and powers. But the very application of the term *being* to all things, shows that the least perfect has as much *being* as the most perfect; or rather that there can be no difference, so far as that word is concerned, between two things to which it is alike applicable. The justness of the compound proportion on which human virtue is made to depend, is capable of being tried by an easy test. If we suppose the greatest of evil spirits to have a hundred times the bad passions of Marcus Aurelius, and at the same time a hundred times his faculties, or, in Edwards's language, a hundred times his quantity of being, it follows from this moral theory, that we ought to esteem and love the devil exactly in the same degree as we esteem and love Marcus Aurelius.

The chief circumstance which justifies so much being said on the last two writers, is their concurrence in a point towards which Ethical Philosophy had been slowly approaching, from the time of the controversies raised up by Hobbes. They both indicate the increase of this tendency, by introducing an element into their theory, foreign from those cold systems of ethical abstraction, with which they continued in other respects to have much in common. Malebranche makes virtue consist in the love of *order*, Edwards in the love of *being.* In this language we perceive a step beyond the representation of Clarke, which made it a conformity to the relations of things; but a step which cannot be made without passing into a new province;—without confessing, by the use of the word *love*, that not only perception and reason, but emotion and sentiment, are among the fundamental principles of morals. They still, however, were so wedded to scholastic prejudice, as to choose two of the most aerial abstractions which can be introduced into argument,—*being* and *order*,—to be the objects of those strong active feelings which were to govern the human mind.

BUFFIER.[2]

THE same strange disposition to fix on abstractions as the objects of our primitive feelings, and the end sought by our warmest desires, manifests itself in the ingenious writer with whom this part of the Dissertation closes, under a form of less dignity than that which it assumes in the hands of Malebranche and Clarke. Buffier, the only Jesuit whose name has a place in the history of Abstract Philosophy, has no peculiar opinions which would have required any mention of him as a moralist, were it not for the just reputation of his treatise on *First Truths*, with which Dr Reid so remarkably, though unaware of its existence, coincides, even in the misapplication of so practical a term as *common sense* to denote the faculty which recognises the truth of First Principles. His philosophical writings[3] are remarkable for that perfect clearness of expression, which, since the great examples of Descartes and Pascal, has been so generally diffused as to have become one of the enviable peculiarities of French philosophical style, and almost of the French language. His ethical doctrine is that most commonly received among philosophers, from Aristotle to Paley and Bentham: " I desire to be happy; but as I live with other men, I cannot be happy without consulting their happiness:" a proposition perfectly true indeed, but far too narrow, as inferring, that in the most benevolent acts a man must pursue only his own interest, from the fact that the practice of benevolence does increase his happiness, and that because a virtuous mind is likely to be the happiest, our observation of that property of virtue is the cause of our love and reverence for it.

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[1] The coincidence of Malebranche with this part of Edwards, is remarkable. Speaking of the Supreme Being, he says, "*Il s'aime invinciblement.*" He adds another more startling expression, "Certainement Dieu ne peut agir que pour lui-même: il n'a point d'autre motif que son amour propre." (*Traité de Morale*, chap. xvii.)

[2] Born in 1661; died in 1737.

[3] *Cours de Sciences.* Paris, 1732, folio.

SECTION VI.

Foundations of a more just Theory of Ethics.

BUTLER—HUTCHESON—BERKELEY—HUME—SMITH—PRICE—HARTLEY—TUCKER—PALEY—BENTHAM—STEWART—BROWN.

From the beginning of ethical controversy to the eighteenth century, it thus appears, that the care of the individual for himself, and his regard for the things which preserve self, were thought to form the first, and, in the opinion of most, the earliest of all the principles which prompt men and other animals to activity; that nearly all philosophers regarded the appetites and desires, which look only to self-gratification, as modifications of this primary principle of self-love; and that a very numerous body considered even the social affections themselves as nothing more than the produce of a more latent and subtile operation of the desire of interest, and of the pursuit of pleasure. It is true, they often spoke otherwise; but it was rather from the looseness and fluctuation of their language, than from distrust in their doctrine. It is true, also, that perhaps all represented the gratifications of virtue as more unmingled, more secure, more frequent, and more lasting, than other pleasures; without which they could neither have retained a hold on the assent of mankind, nor reconciled the principles of their systems with the testimony of their hearts. We have seen how some began to be roused from a lazy acquiescence in this ancient hypothesis, by the monstrous consequences which Hobbes had legitimately deduced from it. A few, of pure minds and great intellect, laboured to render morality disinterested, by tracing it to reason as its source; without considering that reason, elevated indeed far above interest, is also separated by an impassable gulf, from feeling, affection, and passion. At length it was perceived by more than one, that through whatever length of reasoning the mind may pass in its advances towards action, there is placed at the end of any avenue through which it can advance, some principle wholly unlike mere reason,—some *emotion* or *sentiment* which must be touched, before the springs of will and action can be set in motion. Had Lord Shaftesbury steadily adhered to his own principles—had Leibnitz not recoiled from his statement—the truth might have been regarded as promulged, though not unfolded. The writings of both prove, at least to us, enlightened as we are by what followed, that they were skilful in sounding, and that their lead had touched the bottom. But it was reserved for another moral philosopher to determine this hitherto unfathomed depth.[1]

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[1] The doctrine of the Stoics is thus put by Cicero into the mouth of Cato: " Placet his, inquit, quorum ratio mihi probatur, simul atque natum sit animal, (hinc enim est ordiendum) ipsum sibi conciliari et commendari ad se conservandum,

BUTLER.[1]

Butler, who was the son of a Presbyterian trader, early gave such promise, as to induce his father to fit him, by a proper education, for being a minister of that persuasion. He was educated at one of their seminaries under Mr Jones of Gloucester, where Secker, afterwards archbishop of Canterbury, was his fellow-student. Though many of the dissenters had then begun to relinquish Calvinism, the uniform effect of that doctrine, in disposing its adherents to metaphysical speculation, long survived the opinions which caused it, and cannot be doubted to have influenced the mind of Butler. When a student at the academy of Gloucester, he wrote private letters to Dr Clarke on his celebrated *Demonstration*, suggesting objections which were really insuperable, and which are marked by an acuteness which neither himself nor any other ever surpassed. Clarke, whose heart was as well schooled as his head, published the letters, with his own answers, in the next edition of his work; and, by his good offices with his friend and follower, Sir Joseph Jekyll, obtained for the young philosopher an early opportunity of making his abilities and opinions known, by the appointment of preacher at the Chapel of the Master of the Rolls. He was afterwards raised to one of the highest seats on the Episcopal bench, through the philosophical taste of Queen Caroline, and her influence over the mind of her husband, which continued long after her death. "He was wafted," says Horace Walpole, "to the see of Durham, on a cloud of Metaphysics."[2] Even in the fourteenth year of his widowhood, George II. was desirous of inserting the name of the Queen's metaphysical favourite in the Regency Bill of seventeen hundred and fifty-one.

His great work on the *Analogy of Religion to the Course of Nature*, though only a commentary on the singularly original and pregnant passage of Origen, which is so honestly prefixed to it as a motto, is, notwithstanding, the most original and profound work extant in any language on the Philosophy of Religion. It is entirely beyond our present scope. His ethical discussions are contained in those deep and sometimes dark Dissertations which he preached at the Chapel of the Rolls, and afterwards published under the name of *Sermons*, while he was yet fresh from the schools, and full of that courage with which youth often delights to exercise its strength in abstract reasoning, and to push its faculties into the recesses of abstruse speculation. But his youth was that of a sober and mature mind, early taught by nature to discern the boundaries of knowledge, and to abstain from fruitless efforts to reach inaccessible ground. In these sermons,[3] he has taught truths more capable of being exactly distinguished from the doctrines of his predecessors, more satisfactorily established by him, more comprehensively applied to particulars, more rationally connected with each other, and therefore more worthy of the name of *discovery*, than any with which we are acquainted; if we ought not, with some hesitation, to except the first steps of the Grecian philosophers towards a Theory of Morals. It is a peculiar hardship, that the extreme ambiguity of language, an obstacle which it is one of the chief merits of an ethical philosopher to vanquish, is one of the circumstances which prevent men

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et ad suum statum, et ad ea quæ conservantia sunt ejus status diligenda; alienari autem ab interitu, iisque rebus quæ interitum videantur afferre. Id ita esse sic probant, quod, antequam voluptas aut dolor attigerit, salutaria appetant parvi, aspernenturque contraria. Quod non fieret, nisi statum suum diligerent, interitum timerent. *Fieri autem non posset ut appeterent aliquid, nisi sensum haberent sui, eoque se et sua diligerent.* Ex quo intelligi debet, principium ductum esse a se diligendi." (*De Finibus*, lib. iii. cap. v.) We are told that *diligendo* is the reading of an ancient MS. Perhaps the omission of 'a' would be the easiest and most reasonable emendation.

The above passage is perhaps the fullest and plainest statement of the doctrines prevalent till the time of Butler.

[1] Born in 1692; died in 1752.

[2] Walpole's *Memoirs*.

[3] See Sermons i. ii. and iii. On Human Nature; v. On Compassion; viii. On Resentment; ix. On Forgiveness; xi. and xii. On the Love of our Neighbour; and xiii. On the Love of God; together with the excellent Preface.

from seeing the justice of applying to him so ambitious a term as *discovery.* Butler owed more to Lord Shaftesbury than to all other writers besides. He is just and generous towards that philosopher; yet, whoever carefully compares their writings, will without difficulty distinguish the two builders, and the larger as well as more regular and laboured part of the edifice, which is due to Butler.

Mankind have various principles of action; some leading directly to the private good, some immediately to the good of the community. But the private desires are not self-love, or any form of it; for self-love is the desire of a man's own happiness, whereas the object of an appetite or passion is some outward thing. Self-love seeks things as means of happiness; the private appetites seek things, not as means, but as ends. A man eats from hunger, and drinks from thirst; and though he knows that these acts are necessary to life, that knowledge is not the motive of his conduct. No gratification can indeed be imagined without a previous desire. If all the particular desires did not exist independently, self-love would have no object to employ itself about; for there would be no happiness, which, by the very supposition of the opponents, is made up of the gratifications of various desires. No pursuit could be selfish or interested, if there were not satisfactions first gained by appetites which seek their own outward objects without regard to self; which satisfactions compose the mass which is called a man's interest.

In contending, therefore, that the benevolent affections are disinterested, no more is claimed for them than must be granted to mere animal appetites and to malevolent passions. Each of these principles alike seeks its own object, for the sake simply of obtaining it. Pleasure is the result of the attainment, but no separate part of the aim of the agent. The desire that another person may be gratified, seeks that outward object alone, according to the general course of human desire. Resentment is as disinterested as gratitude or pity, but not more so. Hunger or thirst may be, as much as the purest benevolence, at variance with self-love. A regard to our own general happiness is not a vice, but in itself an excellent quality. It were well if it prevailed more generally over craving and short-sighted appetites. The weakness of the social affections, and the strength of the private desires, properly constitute selfishness; a vice utterly at variance with the happiness of him who harbours it, and as such, condemned by self-love. There are as few who attain the greatest satisfaction to themselves, as who do the greatest good to others. It is absurd to say with some, that the pleasure of benevolence is selfish because it is felt by self. Understanding and reasoning are acts of self, for no man can think by proxy; but no one ever called them *selfish.* Why? Evidently because they do not *regard* self. Precisely the same reason applies to benevolence. Such an argument is a gross confusion of self, as it is a *subject* of feeling or thought, with self considered as the *object* of either. It is no more just to refer the private appetites to self-love because they commonly promote happiness, than it would be to refer them to self-hatred in those frequent cases where their gratification obstructs it.

But, besides the private or public desires, and besides the calm regard to our own general welfare, there is a principle in man, in its nature supreme over all others. This natural supremacy belongs to the faculty which surveys, approves, or disapproves the several affections of our minds and actions of our lives. As self-love is superior to the private passions, so conscience is superior to the whole of man. Passion implies nothing but an inclination to follow it; and in that respect passions differ only in force. But no notion can be formed of the principle of reflection, or conscience, which does not comprehend judgment, direction, superintendency. Authority over all other principles of action is a constituent part of the idea of conscience, and cannot be separated from it. Had it strength as it has right, it would govern the world. The passions would have their power but according to their nature, which is to be subject to conscience. Hence we may understand the purpose at which the ancients, perhaps confusedly, aimed, when they laid it down, that virtue consisted in following nature. It is neither easy, nor, for the main object of the moralist, important, to render the doctrines of the ancients by modern language. If Butler returns to this phrase too often, it was rather from the remains of undistinguishing reverence for antiquity, than because he could deem its employment important to his own opinions.

The tie which holds together Religion and Morality, is, in the system of Butler, somewhat different from the common representations, but not less close. Conscience, or the faculty of approving or disapproving, necessarily constitutes the bond of union. Setting out from the belief of Theism, and combining it, as he had entitled himself to do, with the reality of conscience, he could not avoid discovering, that the being who possessed the highest moral qualities, is the object of the highest moral affections. He contemplates the Deity through the moral nature of man. In the case of a being who is to be perfectly loved, " goodness must be the simple actuating principle within him; this being the moral quality which is the immediate object of love." " The highest, the adequate object of this affection, is perfect goodness; which, therefore, we are to love with all our heart, with all our soul, and with all our strength." " We should refer ourselves implicitly to him, and cast ourselves entirely upon him. The whole attention of life should be to obey his commands."[1] Moral distinctions are thus presupposed before a step can be made towards religion: virtue leads to piety; God is to be loved, because goodness is the object of love; and it is only after the mind rises through human morality to divine perfection, that all the virtues and duties are seen to hang from the throne of God.

REMARKS.

There do not appear to be any *errors* in the ethical principles of Butler. The following remarks are intended to point out some *defects* in his scheme; and even that attempt is made with the unfeigned humility of one who rejoices in an opportunity of doing justice to that part of the writings of a great philosopher which has not been so clearly understood, nor so justly estimated by the generality, as his other works.

1. It is a considerable defect, though perhaps unavoidable in a sermon, that he omits all inquiry into the nature and origin of the private appetites, which first appear in human nature. It is implied, but it is not expressed in his reasonings, that there is a time before the child can be called selfish, any more than social, when these appetites seem as it were separately to pursue their distinct objects, long antecedent to the state of mind in which all their gratifications are regarded as forming the mass called happiness. It is hence that they are likened to instincts, in contradiction to their subsequent distinction, which requires reason and experience.[2]

2. Butler shows admirably well, that unless there were principles of action independent of self, there could be no pleasures and no happiness for self-love to watch over. A step farther would have led him to perceive, that self-love is altogether a secondary formation; the result of the joint operation of reason and habit upon the primary principles. It could not have existed without presupposing original appetites and organic gratifications. Had he considered this part of the subject, he would have strengthened his case by showing that self-love is as truly a derived principle, not only as any of the social affections, but as any of the most confessedly acquired passions. It would appear clear, that as self-love is not divested of its self-regarding character by considering it as acquired, so the social affections do not lose any part of their disinterested character, if they be considered as formed from simpler elements. Nothing would more tend to root out the old prejudice which treats a regard to self as analogous to a self-evident principle, than the proof, that self-love is itself formed from certain original elements, and that a living being long subsists before its appearance.[3]

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[1] Sermon xiii. On the Love of God.

[2] The very able work ascribed to Mr Hazlitt, entitled *Essay on the Principles of Human Action*, Lond. 1805, contains original views on this subject.

[3] Compare this statement with the Stoical doctrine explained by Cicero in the book *de Finibus*, quoted above, of which it is the direct opposite.

3. It must be owned that those parts of Butler's discourses which relate to the social affections are more satisfactory than those which handle the question concerning the moral sentiments. It is not that the real existence of the latter is not as well made out as that of the former. In both cases he occupies the unassailable ground of an appeal to consciousness. All men (even the worst) feel that they have a conscience and disinterested affections. But he betrays a sense of the greater vagueness of his notions on this subject. He falters as he approaches it. He makes no attempt to determine in what state of mind the action of conscience consists. He does not venture steadily to denote it by a name. He fluctuates between different appellations, and multiplies the metaphors of authority and command, without a simple exposition of that mental operation which these metaphors should only have illustrated. It commands other principles. But the question recurs, why, or how?

Some of his own hints, and some fainter intimations of Shaftesbury, might have led him to what appears to be the true solution; which, perhaps from its extreme simplicity, has escaped him and his successors. The truth seems to be, that the moral sentiments in their mature state, are *a class of feelings which have no other object but the mental dispositions leading to voluntary action, and the voluntary actions which flow from these dispositions.* We are pleased with some dispositions and actions, and displeased with others, in ourselves and our fellows. We desire to cultivate the dispositions, and to perform the actions, which we contemplate with satisfaction. These objects, like all those of human appetite or desire, are sought for their own sake. The peculiarity of these desires is, that their gratification *requires the use of no means.* Nothing (unless it be a volition) is interposed between the desire and the voluntary act. It is impossible, therefore, that these passions should undergo any change by transfer from the end to the means, as is the case with other practical principles. On the other hand, as soon as they are fixed on these ends, they cannot regard any further object. When another passion prevails over them, the end of the moral faculty is converted into a means of gratification. But volitions and actions are not themselves the end, or last object in view, of any other desire or aversion. Nothing stands between the moral sentiments and their object. They are, as it were, in contact with the will. It is this sort of mental position, if the expression may be pardoned, that explains, or seems to explain those characteristic properties which true philosophers ascribe to them, and which all reflecting men feel to belong to them. Being the only desires, aversions, sentiments, or emotions, which regard dispositions and actions, they *necessarily extend to the whole character and conduct.* Among motives to action, they alone are justly considered as *universal.* They may and do stand between any other practical principle and its object; while it is absolutely impossible that another shall intercept their connection with the will. Be it observed, that though many passions prevail over them, no other can act beyond its own appointed and limited sphere; and that the prevalence itself, leaving the natural order undisturbed in any other part of the mind, is perceived to be a disorder, when seen in another man, and felt to be so by the mind disordered, when the disorder subsides. Conscience may forbid the will to contribute to the gratification of a desire. No desire ever forbids will to obey conscience.

This result of the peculiar relation of conscience to the will, justifies those metaphorical expressions which ascribe to it *authority* and the right of *universal command.* It is *immutable;* for, by the law which regulates all feelings, it must rest on *action,* which is its object, and beyond which it cannot look; and as it employs no *means,* it never can be transferred to nearer objects, in the way in which he who first desires an object as a means of gratification, may come to seek it as his end. Another remarkable peculiarity is bestowed on the moral feelings by the nature of their object. As the objects of all other desires are outward, the satisfaction of them may be frustrated by outward causes. The moral sentiments may always be gratified, because voluntary actions and moral dispositions spring from within. No external circumstance affects them. Hence their *independence.* As the moral sentiment needs *no means,* and the desire is instantaneously followed by the volition, it seems to be either that which first suggests the relation between *command* and *obedience*, or at least that which affords the simplest instance of it. It is therefore with the most rigorous precision that authority and universality are ascribed to them. Their only unfortunate property is their too frequent weakness; but it is apparent that it is from that circumstance alone that their failure arises. Thus considered, the language of Butler concerning conscience, that, " had it strength as it has right it would govern the world," which may seem to be only an effusion of generous feeling, proves to be a just statement of the nature and action of the highest of human faculties. The union of universality, immutability, and independence, with direct action on the will, which distinguishes the moral sense from every other part of our practical nature, renders it scarcely metaphorical language to ascribe to it unbounded sovereignty and awful authority over the whole of the world within;—shows that attributes, well denoted by terms significant of command and control, are, in fact, inseparable from it, or rather constitute its very essence;—justifies those ancient moralists who represent it as alone securing, if not forming the moral liberty of man; and finally, when religion rises from its roots in virtuous feeling, it clothes conscience with the sublime character of representing the divine purity and majesty in the human soul. Its title is not impaired by any number of defeats; for every defeat necessarily disposes the disinterested and dispassionate by-stander to wish that its force were strengthened: and though it may be doubted whether, consistently with the present constitution of human nature, it could be so invigorated as to be the only motive to action, yet every such by-stander rejoices at all accessions to its force; and would own, that man becomes happier, more excellent, more estimable, more venerable, in proportion as conscience acquires a power of banishing malevolent passions, of strongly curbing all the private appetites, of influencing and guiding the benevolent affections themselves.

Let it be carefully considered whether the same observations could be made with truth, or with plausibility, on any other part or element of the nature of man. They are entirely independent of the question, whether conscience be an inherent or an acquired principle. If it be inherent, that circumstance is, according to the common modes of thinking, a sufficient proof of its title to veneration. But if provision be made in the constitution and circumstances of all men, for uniformly producing it, by processes similar to those which produce other acquired sentiments, may not our reverence be augmented by admiration of that supreme wisdom which, in such mental contrivances, yet more brightly than in the lower world of matter, accomplishes mighty purposes by instruments so simple? Should these speculations be thought to have any solidity by those who are accustomed to such subjects, it would be easy to unfold and apply them so fully, that they may be thoroughly apprehended by every intelligent person.

4. The most palpable defect of Butler's scheme is, that it affords no answer to the question, " What is the distinguishing quality common to all right actions?" If it were answered, " Their criterion is, that they are approved and commanded by conscience," the answerer would find that he was involved in a vicious circle; for conscience itself could be no otherwise defined than as the faculty which approves and commands right actions.

There are few circumstances more remarkable than the small number of Butler's followers in Ethics; and it is perhaps still more observable, that his opinions were not so much rejected as overlooked. It is an instance of the importance of style. No thinker so great was ever so bad a writer. Indeed, the ingenious apologies which have been lately attempted for this defect, amount to no more than that his power of thought was too much for his skill in language. How general must the reception have been of truths so certain and momentous as those contained in Butler's Discourses,—with how much more clearness must they have appeared to his own great understanding, if he had possessed the strength and distinctness with which Hobbes enforces odious falsehood, or the unspeakable charm of that transparent diction which clothed the unfruitful paradoxes of Berkeley!

HUTCHESON.[1]

This ingenious writer began to try his own strength by private Letters, written in his early youth to Dr Clarke, the metaphysical patriarch of his time; on whom young philosophers seem to have considered themselves as possessing a claim, which he had too much goodness to reject. His correspondence with Hutcheson is lost; but we may judge of its spirit by his answers to Butler, and by one to Mr Henry Home,[2] afterwards Lord Kames, then a young adventurer in the prevalent speculations. Nearly at the same period with Butler's first publication,[3] the writings of Hutcheson began to show coincidences with him, indicative of the tendency of moral theory to a new form, to which an impulse had been given by Shaftesbury, and which was roused to activity by the adverse system of Clarke. Lord Molesworth, the friend of Shaftesbury, patronised Hutcheson, and even criticised his manuscript. Though a Presbyterian, he was befriended by King, archbishop of Dublin, himself a metaphysician; and he was aided by Mr Synge, afterwards a bishop, to whom speculations somewhat similar to his own had occurred.

Butler and Hutcheson coincided in the two important positions, that disinterested affections, and a distinct moral faculty, are essential parts of human nature. Hutcheson is a chaste and simple writer, who imbibed the opinions, without the literary faults of his master, Shaftesbury. He has a clearness of expression, and fulness of illustration, which are wanting in Butler. But he is inferior to both these writers in the appearance at least of originality, and to Butler especially in that philosophical courage which, when it discovers the fountains of truth and falsehood, leaves others to follow the streams. He states as strongly as Butler, that "the same cause which determines us to pursue happiness for ourselves, determines us both to esteem and benevolence on their proper occasions—even the very frame of our nature."[4] It is vain, as he justly observes, for the patrons of a refined selfishness to pretend that we pursue the happiness of others for the sake of the pleasure which we derive from it; since it is apparent that there could be no such pleasure if there had been no previous affection. "Had we no affection distinct from self-love, nothing could raise a desire of the happiness of others, but when viewed as a mean of our own."[5] He seems to have been the first who entertained just notions of the formation of the secondary desires, which had been overlooked by Butler. "There must arise, in consequence of our original desires, *secondary* desires of every thing useful to gratify the primary desire. Thus, as soon as we apprehend the use of wealth or power to gratify our original desires, we also *desire* them. From their universality as means arises the general prevalence of these desires of wealth and power."[6] Proceeding farther in his zeal against the selfish system than Lord Shaftesbury, who seems ultimately to rest the reasonableness of benevolence on its subserviency to the happiness of the individual, he represents the moral faculty to be, as well as self-love and benevolence, a calm general impulse, which may and does impel a good man to sacrifice not only happiness, but even life itself, to virtue.

As Mr Locke had spoken of an internal sensation,—Lord Shaftesbury once or twice of a reflex sense, and once of a moral sense,—Hutcheson, who had a steadier, if not a clearer view of the nature of conscience than Butler, calls it a *Moral Sense;* a name which quickly became popular, and continues to be a part of philosophical language. By *sense*, he understood a capacity of receiving ideas, together with pleasures and pains, from a class of objects. The term *moral* was used to describe the particular class in question. It implied only that conscience was a separate element in our nature, and that it was not a state or act of the understanding. According to him, it also implied that it was an original and implanted principle; but every other part of his theory might be embraced by those who hold it to be derivative.

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[1] Born in Ireland in 1694; died at Glasgow in 1747.

[2] Woodhouselee's *Life of Lord Kames*, vol. I. Append. No. 3.

[3] The first edition of Butler's Sermons was published in 1726, in which year also appeared the *second* edition of Hutcheson's *Inquiry into Beauty and Virtue.* The Sermons had been preached some years before, though there is no likelihood that the contents could have reached a young teacher at Dublin. The place of Hutcheson's birth is not mentioned in any account known to me. Ireland may be truly said to be "*incuriosa suorum.*"

[4] *Inquiry*, p. 152.

[5] *Essay on the Passions*, p. 17.

[6] *Ibid.* p. 8.

The object of moral approbation, according to him, is general benevolence; and he carries this generous error so far as to deny that prudence, as long as it regards ourselves, can be morally approved;—an assertion contradicted by every man's feelings, and to which we owe the Dissertation on the Nature of Virtue which Butler annexed to his *Analogy*. By proving that all virtuous actions produce general good, he fancied that he had proved the necessity of regarding the general good in every act of virtue;—an instance of that confusion of the theory of moral sentiments with the criterion of moral actions, against which the reader was warned at the opening of this Dissertation, as fatal to Ethical Philosophy. He is chargeable, like Butler, with a vicious circle, in describing virtuous acts as those which are approved by the moral sense, while he at the same time describes the moral sense as the faculty which perceives and feels the morality of actions.

He was the father of speculative philosophy in Scotland, at least in modern times; for though in the beginning of the sixteenth century the Scotch are said to have been known throughout Europe by their unmeasured passion for dialectical subtilties,[1] and though this metaphysical taste was nourished by the controversies which followed the Reformation, yet it languished, with every other intellectual taste and talent, from the Restoration, first silenced by civil disorders, and afterwards repressed by an exemplary but unlettered clergy, till the philosophy of Shaftesbury was brought by Hutcheson from Ireland. We are told by the writer of his Life, (a fine piece of philosophical biography) that "he had a remarkable degree of rational enthusiasm for learning, liberty, religion, virtue, and human happiness;"[2] that he taught in public with persuasive eloquence; that his instructive conversation was at once lively and modest; that he united pure manners with a kind disposition. What wonder that such a man should have spread the love of knowledge and virtue around him, and should have rekindled in his adopted country a relish for the sciences which he cultivated! To him may also be ascribed that proneness to multiply ultimate and original principles in human nature, which characterized the Scottish School till the second extinction of a passion for metaphysical speculation in Scotland. A careful perusal of the writings of this now little studied philosopher will satisfy the well-qualified reader, that Dr Adam Smith's ethical speculations are not so unsuggested as they are beautiful.

BERKELEY.[3]

This great metaphysician was so little a moralist, that it requires the attraction of his name to excuse its introduction here. His *Theory of Vision* contains a great discovery in mental philosophy. His immaterialism is chiefly valuable as a touchstone of metaphysical sagacity; showing those to be altogether without it, who, like Johnson and Beattie, believed that his speculations were sceptical, that they implied any distrust in the senses, or that they had the smallest tendency to disturb reasoning or alter conduct. Ancient learning, exact science, polished society, modern literature, and the fine arts, contributed to adorn and enrich the mind of this accomplished man. All his contemporaries agreed with the satirist in ascribing

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[1] The character given of the Scotch by the famous and unfortunate Servetus, in his edition of Ptolemy, (1533) is in many respects curious. "Gallis amicissimi, Anglorumque regi maxime infesti. Subita ingenia, et in ultionem prona, ferociaque. In bello fortes, inediæ, vigiliæ, algoris patientissimi, decenti forma sed cultu negligentiori; invidi natura et cæterorum mortalium contemptores; ostentant *plus nimio nobilitatem suam, et in summa etiam egestate suum genus ad regiam stirpem referunt*, NEC NON DIALECTICIS ARGUTIIS SIBI BLANDIUNTUR."—*Subita ingenia* is an expression equivalent to the "Præfervidum Scotorum ingenium" of Buchanan. Churchill almost agrees in words with Servetus:

Whose lineage springs
From great and glorious, though forgotten kings.

And the strong antipathy of the late King George III. to what he called "Scotch Metaphysics," proves the permanency of the last part of the national character.

[2] Life by Dr Leechman, prefixed to Hutcheson's *System of Moral Philosophy*, 1755.

[3] Born near Thomastown in Ireland, in 1684; died at Oxford in 1753.

To Berkeley every virtue under heaven.

Adverse factions and hostile wits concurred only in loving, admiring, and contributing to advance him. The severe sense of Swift endured his visions; the modest Addison endeavoured to reconcile Clarke to his ambitious speculations. His character converted the satire of Pope into fervid praise. Even the discerning, fastidious, and turbulent Atterbury said, after an interview with him, "So much understanding, so much knowledge, so much innocence, and such humility, I did not think had been the portion of any but angels, till I saw this gentleman."[1] "Lord Bathurst told me, that the Members of the Scriblerus Club being met at his house at dinner, they agreed to rally Berkeley, who was also his guest, on his scheme at Bermudas. Berkeley, having listened to the many lively things they had to say, begged to be heard in his turn, and displayed his plan with such an astonishing and animating force of eloquence and enthusiasm, that they were struck dumb, and after some pause, rose all up together, with earnestness exclaiming, 'Let us set out with him immediately.'"[2] It was when thus beloved and celebrated that he conceived, at the age of forty-five, the design of devoting his life to reclaim and convert the natives of North America; and he employed as much influence and solicitation as common men do for their most prized objects, in obtaining leave to resign his dignities and revenues, to quit his accomplished and affectionate friends, and to bury himself in what must have seemed an intellectual desert. After four years' residence at Newport in Rhode Island, he was compelled, by the refusal of Government to furnish him with funds for his College, to forego his work of heroic, or rather godlike benevolence; though not without some consoling forethought of the fortune of the country where he had sojourned.

Westward the course of empire takes its way,
  The first four acts already past,
A fifth shall close the drama with the day,
  TIME'S NOBLEST OFFSPRING IS ITS LAST.

Thus disappointed in his ambition of keeping a School for savage children, at a salary of a hundred pounds by the year, he was received, on his return, with open arms by the philosophical queen, at whose metaphysical parties he made one with Sherlock, who, as well as Smalridge, was his supporter, and with Hoadley, who, following Clarke, was his antagonist. By her influence, he was made bishop of Cloyne. It is one of his highest boasts, that though of English extraction, he was a true Irishman, and the first eminent Protestant, after the unhappy contest at the Revolution, who avowed his love for all his countrymen. He asked, "Whether their habitations and furniture were not more sordid than those of the savage Americans?"[3] "*Whether a scheme for the welfare of this nation should not take in the whole inhabitants?*" and, "*Whether it was a vain attempt, to project the flourishing of our Protestant gentry, exclusive of the bulk of the natives?*"[4] He proceeds to promote the reformation suggested in this pregnant question by a series of Queries, intimating, with the utmost skill and address, every reason that proves the necessity, and the safety, and the wisest mode of adopting his suggestion. He contributed, by a truly Christian address to the Roman Catholics of his diocese, to their perfect quiet during the rebellion of 1745; and soon after published a letter to the clergy of that persuasion, beseeching them to inculcate industry among their flocks, for which he received their thanks. He tells them, that it was a saying among the negro slaves, "*if negro were not negro, Irishman would be negro.*" It is difficult to read these proofs of benevolence and foresight without emotion, at the moment when,[5] after a lapse of near a century, his suggestions have been at length, at the close of a struggle of twenty-five years, adopted, by the admission of the whole Irish nation to the privileges of the British Constitution. The patriotism of Berkeley was not, like that of Swift, tainted by disappointed ambition; nor was it, like Swift's, confined to a colony of English Protestants. Perhaps the *Querist* contains more hints, then original, still unapplied in legislation and political economy, than are to be found in any equal space. From the writings of his advanced years, when he chose a medical Tract[1] to be the vehicle of his philosophical reflections, though it cannot be said that he relinquished his early opinions, it is at least apparent that his mind had received a new bent, and was habitually turned from reasoning towards contemplation. His immaterialism indeed modestly appears, but only to purify and elevate our thoughts, and to fix them on Mind, the paramount and primeval principle of all things. "Perhaps," says he, "the truth about innate ideas may be, that there are properly no ideas or passive objects in the mind but what are derived from sense, but that there are also, besides these, her own acts and operations—such are notions;" a statement which seems once more to admit *general conceptions*, and which might have served, as well as the parallel passage of Leibnitz, as the basis of the modern philosophy of Germany. From these compositions of his old age, he appears then to have recurred with fondness to Plato and the later Platonists; writers from whose mere reasonings an intellect so acute could hardly hope for an argumentative satisfaction of all its difficulties, and whom he probably rather studied as a means of inuring his mind to objects beyond the visible diurnal sphere, and of attaching it, through frequent meditation, to that perfect and transcendent goodness to which his moral feelings always pointed, and which they incessantly strove to grasp. His mind, enlarging as it rose, at length receives every theist, however imperfect his belief, to a communion in its philosophic piety. "Truth," he beautifully concludes, "is the cry of all, but the game of a few. Certainly, where it is the chief passion, it does not give way to vulgar cares, nor is it contented with a little ardour in the early time of life; active perhaps to pursue, but not so fit to weigh and revise. He that would make a real progress in knowledge, must dedicate his age as well as youth, the later growth as well as first fruits, at the altar of Truth." So did Berkeley, and such were almost his latest words.

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[1] DUNCOMBE'S *Letters*, 106, 107.

[2] WARTON *on Pope*.

[3] See his *Querist*, 358; published in 1735.

[4] *Ibid.* 255.

[5] April 1829.

His general principles of Ethics may be shortly stated in his own words:—"As God is a being of infinite goodness, his end is the good of his creatures. The general wellbeing of all men of all nations, of all ages of the world, is that which he designs should be procured by the concurring actions of each individual." Having stated that this end can be pursued only in one of two ways—either by computing the consequences of each action, or by obeying rules which generally tend to happiness—and having shown the first to be impossible, he rightly infers, "that the end to which God requires the concurrence of human actions, must be carried on by the observation of certain determinate and universal rules or moral precepts, which in their own nature have a necessary tendency to promote the wellbeing of mankind, taking in all nations and ages, from the beginning to the end of the world."[2] A romance, of which a journey to an Utopia, in the centre of Africa, forms the chief part, called *The Adventures of Signor Gaudentio di Lucca*, has been commonly ascribed to him; probably on no other ground than its union of pleasing invention with benevolence and elegance.[3] Of the exquisite grace and beauty of his diction, no man accustomed to English composition can need to be informed. His works are, beyond dispute, the finest models of philosophical style since Cicero. Perhaps they surpass those of the orator, in the wonderful art by which the fullest light is thrown on the most minute and evanescent parts of the most subtile of human conceptions. Perhaps he also surpassed Cicero in the charm of simplicity, a quality eminently found in Irish writers before the end of the eighteenth century; conspicuous in the masculine severity of Swift, in the Platonic fancy of Berkeley, in the native tenderness and elegance of Goldsmith, and not withholding its attractions from Hutcheson and Leland, writers of classical taste, though of inferior power. The two Irish philosophers of the eighteenth century may be said to have co-operated in calling forth the metaphysical genius of Scotland; for, though Hutcheson spread the taste, and furnished the principles, yet Berkeley undoubtedly produced the scepticism of Hume, which stimulated the instinctive school to activity, and was thought incapable of confutation, otherwise than by their doctrines.

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[1] *Siris*, or *Reflections on Tar Water.*

[2] *Sermon in Trinity College Chapel, on Passive Obedience*, 1712.

[3] *Gentleman's Magazine*, January 1777.

DAVID HUME.[1]

The Life of Mr Hume, written by himself, is remarkable above most, if not all writings of that sort, for hitting the degree of interest between coldness and egotism which becomes a modest man in speaking of his private history. Few writers, whose opinions were so obnoxious, have more perfectly escaped every personal imputation. Very few men of so calm a character have been so warmly beloved. That he approached to the character of a perfectly good and wise man, is an affectionate exaggeration, for which his friend Dr Smith, in the first moments of his sorrow, may well be excused.[2] But such a praise can never be earned without passing through either of the extremes of fortune; without standing the test of temptations, dangers, and sacrifices. It may be said with truth, that the private character of Mr Hume exhibited all the virtues which a man of reputable station, under a mild government, in the quiet times of a civilized country, has often the opportunity to practise. He showed no want of the qualities which fit men for more severe trials. Though others had warmer affections, no man was a kinder relation, a more unwearied friend, or more free from meanness and malice. His character was so simple, that he did not even affect modesty; but neither his friendships nor his deportment were changed by a fame which filled all Europe. His good nature, his plain manners, and his active kindness, procured him at Paris the enviable name of *the good David*, from a society not so alive to goodness, as without reason to place it at the head of the qualities of a celebrated man.[3] His whole character is faithfully and touchingly represented in the story of La Roche,[4] where Mr Mackenzie, without concealing Mr Hume's opinions, brings him into contact with scenes of tender piety, and yet preserves the interest inspired by genuine and unalloyed, though moderated feelings and affections. The amiable and venerable patriarch of Scottish Literature was averse from the opinions of the philosopher on whom he has composed this best panegyric. He tells us that he read the manuscript to Dr Smith, "who declared he did not find a syllable to object to, but added, with his characteristic absence of mind, that he was surprised he had never heard of the anecdote before."[5] So lively was the delineation thus sanctioned by the most natural of all testimonies. Mr Mackenzie indulges his own religious feelings by modestly intimating, that Dr Smith's answer seemed to justify the last words of the tale, "that there were moments when the philosopher recalled to his mind the venerable figure of the good La Roche, and wished that he had never doubted." To those who are strangers to the seductions of paradox, to the intoxication of fame, and to the bewitchment of prohibited opinions, it must be unaccountable, that he who revered benevolence should, without apparent regret, cease to see it on the Throne of the Universe. It is a matter of wonder that his habitual esteem for every fragment and shadow of moral excellence should not lead him to envy those who contemplated its perfection in that living and paternal character which gives it a power over the human heart.

On the other hand, if we had no experience of the power of opposite opinions in producing irreconcilable animosities, we might have hoped that those who retained such high privileges would have looked with more compassion than dislike on a virtuous man who had lost them. In such cases it is too little remembered, that repugnance to hypocrisy, and impatience of long concealment, are the qualities of the best formed minds; and that, if the publication of some doctrines proves often painful and mischievous, the habitual suppression of opinion is injurious to reason, and very dangerous to sincerity. Practical questions thus arise, so difficult and perplexing, that their determination generally depends on the boldness or timidity of the individual,—on his tenderness for the feelings of the good, or his greater reverence for the free exercise of reason. The time is not yet come when the noble maxim of Plato, "that every soul is *unwillingly* deprived of truth," will be practically and heartily applied by men to the honest opponents who differ from them most widely.

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[1] Born at Edinburgh in 1711; died there in 1776.
[2] Dr Smith's Letter to Mr Strahan, annexed to the Life of Hume.
[3] See Notes and Illustrations, note P.
[4] Mirror, Nos. 42, 43, 44.
[5] MACKENZIE'S *Life of John Home*, p. 21.

In his twenty-seventh year he published at London the *Treatise of Human Nature*, the first systematic attack on all the principles of knowledge and belief, and the most formidable, if universal scepticism could ever be more than a mere exercise of ingenuity.[1] This memorable work was reviewed in a Journal of that time,[2] in a criticism not distinguished by ability, which affects to represent the style of a very clear writer as unintelligible—sometimes from a purpose to insult, but oftener from sheer dulness—which is unaccountably silent respecting the consequences of a sceptical system; and which concludes with a prophecy so much at variance with the general tone of the article, that it would seem to be added by a different hand. "It bears incontestable marks of a great capacity, of a soaring genius, but young, and not yet thoroughly practised. Time and use may ripen these qualities in the author, and we shall probably have reason to consider this, compared with his later productions, in the same light as we view the juvenile works of Milton, or the first manner of Raphael."

The great speculator did not, in this work, amuse himself, like Bayle, with dialectical exercises, which only inspire a disposition towards doubt, by showing in detail the uncertainty of most opinions. He aimed at proving, not that nothing was known, but that nothing could be known;—from the structure of the understanding to demonstrate, that we are doomed for ever to dwell in absolute and universal ignorance. It is true that such a system of universal scepticism never can be more than an intellectual amusement, an exercise of subtilty; of which the only use is to check dogmatism, but which perhaps oftener provokes and produces that much more common evil. As those dictates of experience which regulate conduct must be the objects of belief, all objections which attack them in common with the principles of reasoning must be utterly ineffectual. Whatever attacks every principle of belief can destroy none. As long as the foundations of knowledge are allowed to remain on the same level (be it called of certainty or uncertainty) with the maxims of life, the whole system of human conviction must continue undisturbed. When the sceptic boasts of having involved the results of experience and the elements of geometry in the same ruin with the doctrines of religion and the principles of philosophy, he may be answered, That no dogmatist ever claimed more than the same degree of certainty for these various convictions and opinions; and that his scepticism, therefore, leaves them in the relative condition in which it found them. No man knew better, or owned more frankly than Mr Hume, that to this answer there is no serious reply. Universal scepticism involves a contradiction in terms. *It is a belief that there can be no belief.* It is an attempt of the mind to act without its structure, and by other laws than those to which its nature has subjected its operations. To reason without assenting to the principles on which reasoning is founded, is not unlike an effort to feel without nerves, or to move without muscles. *No man can be allowed to be an opponent in reasoning, who does not set out with admitting all the principles, without the admission of which it is impossible to reason.*[1] It is indeed a puerile, nay, in the eye of wisdom, a childish play, to attempt either to establish or to confute principles by argument, which every step of that argument must presuppose. The only difference between the two cases is, that he who tries to prove them can do so only by first taking them for granted; and that he who attempts to impugn them falls at the very first step into a contradiction, from which he never can rise.

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[1] Sextus, a physician of the empirical, *i. e.* anti-theoretical school, who lived at Alexandria in the reign of Antoninus Pius, has preserved the reasonings of the ancient Sceptics as they were to be found in their most improved state, in the writings of Ænesidemus, a Cretan, who was a Professor in the same city, soon after the reduction of Egypt into a Roman province. The greater part of the grounds of doubt are very shallow and popular. There are, among them, intimations of the argument against a necessary connection of causes with effects, afterwards better presented by Glanville in his *Scepsis Scientifica.* See Notes and Illustrations, note Q.

[2] *History of the Works of the Learned*, November and December 1739, p. 353–404. This Review is attributed by some (CHALMERS, *Biographical Dictionary*) to Warburton, but certainly without foundation.

It must, however, be allowed, that universal scepticism has practical consequences of a very mischievous nature. This is because its *universality* is not steadily kept in view, and constantly borne in mind. If it were, the above short and plain remark would be an effectual antidote to the poison. But in practice, it is an armoury from which weapons are taken to be employed against *some* opinions, while it is hidden from notice that the same weapon would equally cut down every other conviction. It is thus that Mr Hume's theory of causation is used as an answer to arguments for the existence of the Deity, without warning the reader that it would equally lead him not to expect that the sun will rise to-morrow. It must also be added, that those who are early accustomed to dispute first principles are never likely to acquire, in a sufficient degree, that earnestness and that sincerity, that strong love of truth, and that conscientious solicitude for the formation of just opinions, which are not the least virtues of men, but of which the cultivation is the more especial duty of all who call themselves philosophers.[2]

It is not an uninteresting fact, that Mr Hume having been introduced by Lord Kames (then Mr Henry Home) to Dr Butler, sent a copy of his Treatise to that philosopher at the moment of his preferment to the bishopric of Durham; and that the perusal of it did not deter the philosophic prelate from "everywhere recommending Mr Hume's *Moral and Political Essays*,"[3] published two years afterwards;—Essays which it would indeed have been unworthy of such a man not to have liberally commended, for they, and those which followed them, whatever may be thought of the contents of some of them, must be ever regarded as the best models in any language, of the short but full, of the clear and agreeable, though deep discussion of difficult questions.

Mr Hume considered his *Enquiry concerning the Principles of Morals* as the best of his writings. It is very creditable to his character, that he should have looked back with most complacency on a Tract the least distinguished by originality, and the least tainted with paradox, among his philosophical works; but deserving of all commendation for the elegant perspicuity of the style, and the novelty of illustration and inference with which he unfolded to general readers a doctrine too simple, too certain, and too important, to remain till his time undiscovered among philosophers. His diction has, indeed, neither the grace of Berkeley nor the strength of Hobbes; but it is without the verbosity of the former, or the rugged sternness of the latter. His manner is more lively, more easy, more ingratiating, and, if the word may be so applied, more amusing, than that of any other metaphysical writer.[1] He knew himself too well to be, as Dr Johnson asserted, an imitator of Voltaire; who, as it were, embodied in his own person all the wit and quickness and versatile ingenuity of a people which surpasses other nations in these brilliant qualities. If he must be supposed to have had an eye on any French writer, it would be a more plausible guess, that he sometimes copied, with a temperate hand, the unexpected thoughts and familiar expressions of Fontenelle. Though he carefully weeded his writings in their successive editions, yet they still contain Scotticisms and Gallicisms enough to employ the successors of such critics as those who exulted over the Patavinity of the Roman Historian. His own great and modest mind would have been satisfied with the praise which cannot be withheld from him, that there is no writer in our language who, through long works, is more agreeable; and it is no derogation from him, that, as a Scotsman, he did not reach those native and secret beauties, characteristical of a language, which are never attained, in elaborate composition, but by a very small number of those who familiarly converse in it from infancy.

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[1] This maxim, which contains a sufficient answer to all universal scepticism, or, in other words, to all scepticism properly so called, is significantly conveyed in the quaint title of an old and rare book, entitled, *Scivi, sive Sceptices et Scepticorum a Jure Disputationis Exclusio*, by THOMAS WHITE, the metaphysician of the English Catholics in modern times.—"Fortunately," says the illustrious sceptic himself, "*since Reason is incapable of dispelling these clouds, Nature herself suffices for that purpose, and cures me of this philosophical delirium*" (*Treatise of Human Nature*, I. 467); almost in the sublime and immortal words of Pascal: *La Raison confond les Dogmatistes, et la Nature les Sceptiques.*

[2] It would be an act of injustice to those readers who are not acquainted with that valuable volume entitled, *Essays on the Formation of Opinions*, not to refer them to it as enforcing that neglected part of morality. To it may be added, a masterly article in the *Westminster Review*, occasioned by the *Essays.*

[3] WOODHOUSELEE'S *Life of Kames*, I. 86, 104.

The *Enquiry* affords perhaps the best specimen of his style. In substance, its chief merit is the proof, from an abundant enumeration of particulars, that all the qualities and actions of the mind which are generally approved by mankind agree in the circumstance of being useful to society. In the proof, (scarcely necessary) that benevolent affections and actions have that tendency, he asserts the real existence of these affections with unusual warmth; and he well abridges some of the most forcible arguments of Butler,[2] whom it is remarkable that he does not mention. To show the importance of his principle, he very unnecessarily distinguishes the comprehensive duty of justice, from other parts of morality, as an artificial virtue, for which our respect is solely derived from notions of utility. If all things were in such plenty that there could never be a want, or if men were so benevolent as to provide for the wants of others as much as for their own, there would, says he, in neither case be any justice, because there would be no need for it. But it is evident that the same reasoning is applicable to every good affection and right action. None of them could exist if there were no scope for their exercise. If there were no suffering, there could be no pity and no relief. If there were no offences, there could be no placability. If there were no crimes, there could be no mercy. Temperance, prudence, patience, magnanimity, are qualities of which the value depends on the evils by which they are respectively exercised.[3]

On purity of manners, it must be owned that Mr Hume, though he controverts no rule, yet treats vice with too much indulgence. It was his general disposition to distrust virtues which are liable to exaggeration, and may be easily counterfeited. The ascetic pursuit of purity, and hypocritical pretences to patriotism, had too much withdrawn the respect of his equally calm and sincere nature from these excellent virtues; more especially as severity in both these respects was often at apparent variance with affection, which can neither be long assumed, nor ever overvalued. Yet it was singular that he who, in his Essay on *Polygamy and Divorce*,[4] had so well shown the connection of domestic ties with the outward order of society, should not have perceived their deeper and closer relation to all the social feelings of human nature. It cannot be enough regretted, that, in an Enquiry written with a very moral purpose, his habit of making truth attractive, by throwing over her the dress of paradox, should have given him for a moment the appearance of weighing the mere amusements of society and conversation against domestic fidelity, which is the preserver of domestic affection, the source of parental fondness and filial regard, and, indirectly, of all the kindness which exists between human beings. That families are schools where the infant heart learns to love, and that pure manners are the cement which alone holds these schools together, are truths so certain, that it is wonderful he should not have betrayed a stronger sense of their importance. No one could so well have proved that all the virtues of that class, in their various orders and degrees, minister to the benevolent affections; and that every act which separates the senses from the affections tends, in some degree, to deprive kindness of its natural auxiliary, and to lessen its prevalence in the world. It did not require his sagacity to discover that the gentlest and tenderest feelings flourish only under the stern guardianship of these severe virtues. Perhaps his philosophy was loosened, though his life was untainted, by that universal and undistinguishing profligacy which prevailed on the Continent, from the regency of the Duke of Orleans to the French revolution; the most dissolute period of European history, at least since the Roman emperors.[1] At Rome, indeed, the connection of licentiousness with cruelty, which, though scarcely traceable in individuals, is generally very observable in large masses, bore a fearful testimony to the value of austere purity. The alliance of these remote vices seemed to be broken in the time of Mr Hume. Pleasure, in a more improved state of society, seemed to return to her more natural union with kindness and tenderness, as well as with refinement and politeness. Had he lived fourteen years longer, however, he would have seen, that the virtues which guard the natural seminaries of the affections are their only true and lasting friends. The demand of all well-informed men for the improvement of civil institutions—the demand of classes of men growing in intelligence, to be delivered from a degrading inferiority, and admitted to a share of political power proportioned to their new importance, being feebly yet violently resisted by those ruling Castes who neither knew how to yield nor how to withstand—being also attended by very erroneous principles of legislation, having suddenly broken down the barriers (imperfect as these were) of law and government, led to popular excesses, desolating wars, and a military dictatorship, which for a long time threatened to defeat the reformation, and to disappoint the hopes of mankind. This tremendous convulsion threw a fearful light on the ferocity which lies hid under the arts and pleasures of corrupted nations; as earthquakes and volcanoes disclose the layers which compose the deeper parts of our planet, beneath a fertile and flowery surface. A part of this dreadful result may be ascribed, not improbably, to that relaxation of domestic ties, unhappily natural to the populace of vast capitals, and at that time countenanced and aggravated by the example of their superiors. Another part doubtless arose from the barbarizing power of absolute government, or, in other words, of injustice in high places. A very large portion attests, as strongly as Roman history, though in a somewhat different manner, the humanizing efficacy of the family virtues, by the consequences of the want of them in the higher classes, whose profuse and ostentatious sensuality inspired the laborious and suffering portion of mankind with contempt, disgust, envy, and hatred.

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[1] These commendations are so far from being at variance with the remarks of the late most ingenious Dr Thomas Brown, on Mr Hume's "mode of writing," (*Enquiry into the Relation of Cause and Effect*, 3d ed. 327) that they may rather be regarded as descriptive of those excellencies of which the excess produced the faults of Mr Hume as a mere searcher and teacher; justly, though perhaps severely, animadverted on by Dr Brown.

[2] *Enquiry*, sect. ii. part i., especially the concluding paragraphs; those which precede being more his own.

[3] "Si nobis, cum ex hac vita migraverimus, in beatorum insulis, ut fabulæ ferunt, immortale ævum degere liceret, quid opus esset eloquentia, cum judicia nulla fierent? aut ipsis etiam virtutibus? Nec enim fortitudine indigeremus, nullo proposito aut labore aut periculo; *nec justitia, cum esset nihil quod appeteretur alieni;* nec temperantia, quæ regeret eas quæ nullæ essent libidines: ne prudentia quidem egeremus, nullo proposito delectu bonorum et malorum. Una igitur essemus beati cognitione rerum et scientia." (CICERO. *Fragm.* ap. AUGUSTIN. *de Trinit.* iv. 2.) Cicero is more extensive, and therefore more consistent, than Hume; but his enumeration errs both by excess and defect. He supposes knowledge to render beings happy in this imaginary state, without stooping to inquire how. He omits a virtue which might well exist in it, though we cannot conceive its formation in such a state—the delight in each other's wellbeing; and he omits a conceivable though unknown vice, that of unmixed ill-will, which would render such a state a hell to the wretch who harboured the malevolence.

[4] *Essays and Treatises*, vol I.

The *Enquiry* is disfigured by another speck of more frivolous paradox. It consists in the attempt to give the name of virtue to qualities of the *understanding;* and it would not have deserved the single remark about to be made on it, had it been the paradox of an inferior man. He has altogether omitted the circumstance on which depends the difference of our sentiments regarding moral and intellectual qualities. We

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[1] See Notes and Illustrations, note R.

admire intellectual excellence, but we bestow no moral *approbation* on it. Such approbation has no tendency directly to increase it, because it is not voluntary. We cultivate our natural disposition to esteem and love benevolence and justice, because these moral sentiments, and the expression of them, directly and materially dispose others, as well as ourselves, to cultivate these two virtues. We cultivate a natural anger against oppression, which guards ourselves against the practice of that vice, and because the manifestation of it deters others from its exercise. The first rude resentment of a child is against every instrument of hurt. We confine it to intentional hurt, when we are taught by experience that it prevents only that species of hurt; and at last it is still further limited to *wrong* done to ourselves or others, and in that case becomes a purely moral sentiment. We morally approve industry, desire of knowledge, love of truth, and all the habits by which the understanding is strengthened and rectified, because their formation is subject to the will.[1] But we do not feel a moral anger against folly or ignorance, because they are involuntary. No one but the religious persecutor, a mischievous and overgrown child, wreaks his vengeance on involuntary, inevitable, compulsory acts or states of the understanding, which are no more affected by blame than the stone which the foolish child beats for hurting him. Reasonable men apply to every thing which they wish to move, the agent which is capable of moving it;—force to outward substances, arguments to the understanding, and blame, together with all other motives, whether moral or personal, to the will alone. It is as absurd to entertain an abhorrence of intellectual inferiority or error, however extensive or mischievous, as it would be to cherish a warm indignation against earthquakes or hurricanes. It is singular that a philosopher who needed the most liberal toleration should, by representing states of the understanding as moral or immoral, have offered the most philosophical apology for persecution.

That general utility constitutes a uniform ground of moral distinctions, is a part of Mr Hume's ethical theory which never can be impugned, until some example can be produced of a virtue generally pernicious, or of a vice generally beneficial. The religious philosopher who, with Butler, holds that benevolence must be the actuating principle of the Divine mind, will, with Berkeley, maintain that pure benevolence can prescribe no rules of human conduct but such as are beneficial to men; thus bestowing on the theory of *Moral Distinctions* the certainty of demonstration in the eyes of all who believe in God.

The other question of moral philosophy which relates to the theory of *Moral Approbation*, has been by no means so distinctly and satisfactorily handled by Mr Hume. His general doctrine is, that an interest in the wellbeing of others, implanted by nature, which he calls *Sympathy* in his *Treatise of Human Nature*, and much less happily *Benevolence* in his subsequent *Enquiry*,[2] prompts us to be pleased with all generally beneficial actions. In this respect his doctrine nearly resembles that of Hutcheson. He does not trace his principle through the variety of forms which our moral sentiments assume. There are very important parts of them, of which it affords no solution. For example, though he truly represents our approbation, in others, of qualities useful to the individual, as a proof of benevolence, he makes no attempt to explain our moral approbation of such virtues as temperance and fortitude in ourselves. He entirely overlooks that consciousness of the *rightful supremacy of the moral faculty* over every other principle of human action, without an explanation of which, ethical theory is wanting in one of its vital organs.

Notwithstanding these considerable defects, his proof from induction of the beneficial tendency of virtue, his conclusive arguments for human disinterestedness, and his decisive observations on the respective provinces of reason and sentiment in morals, concur in ranking the

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[1] "In hac quæstione primas tenet Voluntas, *qua*, ut ait Augustinus, *peccatur, et recte vivitur.*" (*Hyperaspistes, Diatribe adversus Servum Arbitrium* Martini Lutheri, *per* Desiderium Erasmum Rotterdamensem.)

[2] *Essays and Treatises*, vol. II.

Enquiry with the ethical treatises of the highest merit in our language,—with Shaftesbury's *Enquiry concerning Virtue*, Butler's *Sermons*, and Smith's *Theory of Moral Sentiments.*

ADAM SMITH.[1]

The great name of Adam Smith rests upon the *Enquiry into the Nature and Causes of the Wealth of Nations;* perhaps the only book which produced an immediate, general, and irrevocable change in some of the most important parts of the legislation of all civilized states. The works of Grotius, of Locke, and of Montesquieu, which bear a resemblance to it in character, and had no inconsiderable analogy to it in the extent of their popular influence, were productive only of a general amendment, not so conspicuous in particular instances, as discoverable, after a time, in the improved condition of human affairs.[2] The work of Smith, as it touched those matters which may be numbered, and measured, and weighed, bore more visible and palpable fruit. In a few years it began to alter laws and treaties, and has made its way, throughout the convulsions of revolution and conquest, to a due ascendant over the minds of men, with far less than the average obstructions of prejudice and clamour, which choak the channels through which truth flows into practice. The most eminent of those who have since cultivated and improved the science will be the foremost to address their immortal master,

> .... Tenebris tantis *tam clarum extollere lumen*
> Qui primus potuisti, INLUSTRANS COMMODA VITÆ,
> Te sequor! (LUCRET. lib. iii.)

In a science more difficult, because both ascending to more simple general principles, and running down through more minute applications, though the success of Smith has been less complete, his genius is not less conspicuous. Perhaps there is no ethical work since Cicero's *Offices*, of which an abridgement enables the reader so inadequately to estimate the merit, as the *Theory of Moral Sentiments.* This is not chiefly owing to the beauty of diction, as in the case of Cicero; but to the variety of explanations of life and manners which embellish the book often more than they illuminate the theory. Yet, on the other hand, it must be owned that, for purely philosophical purposes, few books more need abridgement: for the most careful reader frequently loses sight of principles buried under illustrations. The naturally copious and flowing style of the author is generally redundant, and the repetition of certain formularies of the system is, in the later editions, so frequent as to be wearisome, and sometimes ludicrous. Perhaps Smith and Hobbes may be considered as forming the two extremes of good style in our philosophy; the first of graceful fulness falling into flaccidity; while the masterly concision of the second is oftener tainted by dictatorial dryness. Hume and Berkeley, though they are nearer the extreme of abundance,[3] are probably the least distant from perfection.

That mankind are so constituted as to sympathize with each other's feelings, and to feel pleasure in the accordance of these feelings, are the only facts required by Dr Smith, and they certainly must be granted to him. To adopt the feelings of another, is to *approve* them. When the sentiments of another are such as would be excited in us by the same objects, we approve them as *morally proper.* To obtain this accord, it becomes necessary for him who enjoys or suffers, to lower his expression of feeling to the point to which the by-stander can raise his fellow-feelings; on which are founded all the high virtues of self-denial and self-command; and it is equally necessary for the by-stander to raise his sympathy as near as he can to the level of the original feeling. In all unsocial passions, such as anger, we have a *divided sympathy* between him who feels them and those who are the objects of them. Hence the propriety of extremely moderating them. Pure malice is always to be concealed or disguised, because all *sympathy* is arrayed against it. In the private passions, where there is only a *simple sympathy*—that with the original passion—the expression has more liberty. The benevolent affections, where there is a *double sympathy*—with those who feel them, and those who are their objects—are the most agreeable, and may be indulged with the least apprehension of finding no echo in other breasts. Sympathy with the gratitude of those who are benefited by good actions, prompts us to consider them as deserving of reward, and forms the *sense of merit;* as fellow-feeling with the resentment of those who are injured by crimes leads us to look on them as worthy of punishment, and constitutes the *sense of demerit.* These sentiments require not only beneficial actions, but benevolent motives for them; being compounded, in the case of merit, of a direct sympathy with the good disposition of the benefactor, and an indirect sympathy with the persons benefited; in the opposite case, with precisely opposite sympathies. He who does an act of wrong to another to gratify his own passions, must not expect that the spectators, who have none of his undue partiality to his own interest, will enter into his feelings. In such a case, he knows that they will pity the person wronged, and be full of indignation against him. When he is cooled, he adopts the sentiments of others on his own crime, feels *shame* at the *impropriety* of his former passion, pity for those who have suffered by him, and a dread of punishment from general and just resentment. Such are the constituent parts of remorse.

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[1] Born in 1723; died in 1790.
[2] Notes and Illustrations, note S.
[3] This remark is chiefly applicable to Hume's *Essays.* His *Treatise of Human Nature* is more Hobbian in its general tenor, though it has Ciceronian passages.

Our moral sentiments respecting *ourselves* arise from those which others feel concerning us. We feel a self-approbation whenever we believe that the general feeling of mankind coincides with that state of mind in which we ourselves were at a given time. "We suppose ourselves the spectators of our own behaviour, and endeavour to imagine what effect it would in this light produce in us." We must view our own conduct with the eyes of others before we can judge it. The sense of duty arises from putting ourselves in the place of others, and adopting their sentiments respecting our own conduct. In utter solitude there could have been no self-approbation. The *rules* of morality are a summary of those sentiments; and often beneficially stand in their stead when the self-delusions of passion would otherwise hide from us the non-conformity of our state of mind with that which, in the circumstances, can be entered into and approved by impartial bystanders. It is hence that we learn to raise our mind above local or temporary clamour, and to fix our eyes on the surest indications of the general and lasting sentiments of human nature. "When we approve of any character or action, our sentiments are derived from four sources: *first,* we sympathize with the motives of the agent; *secondly,* we enter into the gratitude of those who have been benefited by his actions; *thirdly,* we observe that his conduct has been agreeable to the general rules by which those two sympathies generally act; and, last of all, when we consider such actions as forming part of a system of behaviour which tends to promote the happiness either of the individual or of society, they appear to derive a beauty from this utility, not unlike that which we ascribe to any well-contrived machine."[1]

REMARKS.

That Smith is the first who has drawn the attention of philosophers to one of the most curious and important parts of human nature—who has looked closely and steadily into the workings of *Sympathy,* its sudden action and reaction, its instantaneous conflicts and its emotions, its minute play and varied illusions—is sufficient to place him high among the cultivators of mental philosophy.

He is very original in applications and explanations; though, for his principle, he is somewhat indebted to Butler, more to Hutcheson, and most of all to Hume. These writers, except Hume in his original work, had derived sympathy, or great part of it, from benevolence.[1] Smith, with deeper insight, inverted the order. The great part performed by various sympathies in moral approbation was first unfolded by him; and besides its intrinsic importance, it strengthened the proofs against those theories which ascribe that great function to Reason. Another great merit of the theory of sympathy is, that it brings into the strongest light that most important characteristic of the moral sentiments which consists in their being the only principles leading to action, and dependent on emotion or sensibility, with respect to the objects of which, it is not only possible but natural for all mankind to agree.[2]

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[1] *Theory of Moral Sentiments,* II. 304. Edinb. 1801.

The main defects of this theory seem to be the following.

1. Though it is not to be condemned for declining inquiry into the origin of our fellow-feeling, which, being one of the most certain of all facts, might well be assumed as ultimate in speculations of this nature, it is evident that the circumstances to which some speculators ascribe the formation of sympathy at least contribute to strengthen or impair, to contract or expand it. It will appear, more conveniently, in the next article, that the theory of sympathy has suffered from the omission of these circumstances. For the present, it is enough to observe how much our compassion for various sorts of animals, and our fellow-feeling with various races of men, are proportioned to the resemblance which they bear to ourselves, to the frequency of our intercourse with them, and to other causes which, in the opinion of some, afford evidence that sympathy itself is dependent on a more general law.

2. Had Smith extended his view beyond the mere play of sympathy itself, and taken into account all its preliminaries, and accompaniments, and consequences, it seems improbable that he should have fallen into the great error of representing the sympathies in their primitive state, without undergoing any transformation, as continuing exclusively to constitute the moral sentiments. He is not content with teaching that they are the roots out of which these sentiments grow, the stocks on which they are grafted, the elements of which they are compounded;—doctrines to which nothing could be objected but their unlimited extent. He tacitly assumes, that if a sympathy in the beginning caused or formed a moral approbation, so it must ever continue to do. He proceeds like a geologist who should tell us that the layers of this planet had always been in the same state, shutting his eyes to transition states and secondary formations; or like a chemist who should inform us that no compound substance can possess new qualities entirely different from those which belong to its materials. His acquiescence in this old and still general error is the more remarkable, because Mr Hume's beautiful *Dissertation on the Passions*[3] had just before opened a striking view of some of the compositions and decompositions which render the mind of a formed man as different from its original state, as the organization of a complete animal is from the condition of the first dim speck of vitality. It is from this oversight (ill supplied by moral rules, a loose stone in his building) that he has exposed himself to objections founded on experience, to which it is impossible to attempt any answer. For it is certain that in many, nay in most cases of moral approbation, the adult man approves the action or disposition merely *as right*, and with a distinct consciousness that no process of sympathy intervenes between the approval and its object. It is certain that an unbiassed person would call it *moral approbation*, only as far as it excluded the interposition of any reflection between the conscience and the mental state approved. Upon the supposition of an unchanged state of our active principles, it would follow that sympathy never had any share in the greater part of them. Had he admitted the sympathies to be only elements entering into the *formation of Conscience*, their disappearance, or their appearance only as auxili-

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[1] There is some confusion regarding this point in Butler's first sermon on Compassion.

[2] The feelings of beauty, grandeur, and whatever else is comprehended under the name of Taste, form no exception, for *they do not lead to action*, but terminate in delightful contemplation; which constitutes the essential distinction between them and the moral sentiments, to which, in some points of view, they may doubtless be likened.

[3] *Essays and Treatises*, vol. II.

aries, after the mind is mature, would have been no more an objection to his system, than the conversion of a substance from a transitional to a permanent state is a perplexity to the geologist. It would perfectly resemble the destruction of qualities, which is the ordinary effect of chemical composition.

3. The same error has involved him in another difficulty perhaps still more fatal. The sympathies have nothing more of an *imperative* character than any other emotions. They attract or repel like other feelings, according to their intensity. If, then, the sympathies continue in mature minds to constitute the whole of conscience, it becomes utterly impossible to explain the character of command and supremacy, which is attested by the unanimous voice of mankind to belong to that faculty, and to form its essential distinction. Had he adopted the other representation, it would be possible to conceive, perhaps easy to explain, that conscience should possess a quality which belonged to none of its elements.

4. It is to this representation that Smith's theory owes that unhappy appearance of rendering the rule of our conduct dependent on the notions and passions of those who surround us, of which the utmost efforts of the most refined ingenuity have not been able to divest it. This objection or topic is often ignorantly urged; the answers are frequently solid; but to most men they must always appear to be an ingenious and intricate contrivance of cycles and epicycles, which perplex the mind too much to satisfy it, and seem devised to evade difficulties which cannot be solved. All theories which treat conscience as built up by circumstances inevitably acting on all human minds, are, indeed, liable to somewhat of the same misconception; unless they place in the strongest light (what Smith's theory excludes) the total destruction of the scaffolding which was necessary only to the erection of the building, after the mind is adult and mature, and warn the hastiest reader, that it then rests on its own foundation alone.

5. The constant reference of our own dispositions and actions to the point of view from which they are estimated by others, seems to be rather an excellent expedient for preserving our impartiality, than a fundamental principle of Ethics. But impartiality, which is no more than a removal of some hinderance to right judgment, supplies no materials for its exercise, and no rule, or even principle, for its guidance. It nearly coincides with the Christian precept of doing unto others as we would they should do unto us; an admirable practical maxim, but, as Leibnitz has said truly, intended only as a correction of self-partiality.

6. Lastly, this ingenious system renders all morality *relative*,—by referring it to the pleasure of an agreement of our feelings with those of others, by confining itself entirely to the question of moral approbation, and by providing no place for the consideration of that quality which distinguishes all good from all bad actions;—a defect which will appear in the sequel to be more immediately fatal to a theorist of the *sentimental*, than to one of the *intellectual* school. Smith shrinks from considering utility in that light as soon as it presents itself, or very strangely ascribes its power over our moral feelings to admiration of the mere adaptation of means to ends,—which might surely be as well felt for the production of wide-spread misery, by a consistent system of wicked conduct,—instead of ascribing it to benevolence, with Hutcheson and Hume, or to an extension of that very sympathy which is his own first principle.

RICHARD PRICE.[1]

About the same time with the celebrated work of Smith, but with a popular reception very different, Dr Richard Price, an excellent and eminent non-conformist minister, published *A Review of the principal Questions in Morals*;[2]—an attempt to revive the intellectual theory of moral obligation, which seemed to have fallen under the attacks of Butler, Hutcheson, and Hume, even before Smith. It attracted little observation at first; but being afterwards countenanced by the Scottish School, may seem to deserve some notice, at a moment when the kindred speculations of the German metaphysicians have effected an establishment in France, and are no longer unknown in England.

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[1] Born in 1723; died in 1791.

[2] The third edition was published at London in 1787.

The understanding itself is, according to Price, an independent source of simple ideas. "The various kinds of agreement and disagreement between our ideas, spoken of by Locke, are so many new simple ideas." "This is true of our ideas of proportion, of our ideas of identity and diversity, existence, connection, cause and effect, power, possibility, and of our ideas of right and wrong." "The first relates to quantity, the last to actions, the rest to all things." "Like all other simple ideas, they are undefineable."

It is needless to pursue this theory farther, till an answer shall be given to the observation made before, that as no perception or judgment, or other unmixed act of understanding, merely as such, and without the agency of some intermediate *emotion*, can affect the will, the account given by Dr Price of perceptions or judgments respecting moral subjects, does not advance one step towards the explanation of the authority of conscience over the will, which is the matter to be explained. Indeed, this respectable writer felt the difficulty so much as to allow, "that in contemplating the acts of moral agents, we have both a perception of the understanding and a feeling of the heart." He even admits, that it would have been highly pernicious to us if our reason had been left without such support. But he has not shown how, on such a supposition, we could have acted on a mere opinion; nor has he given any proof that what he calls *support* is not, in truth, the whole of what directly produces the conformity of voluntary acts to morality.[1]

DAVID HARTLEY.[2]

THE work of Dr Hartley, entitled *Observations on Man*,[3] is distinguished by an uncommon union of originality with modesty, in unfolding a simple and fruitful principle of human nature. It is disfigured by the absurd affectation of mathematical forms then prevalent; and it is encumbered and deformed by a mass of physiological speculations, groundless, or at best uncertain, wholly foreign from its proper purpose, which repel the inquirer into mental philosophy from its perusal, and lessen the respect of the physiologist for the author's judgment. It is an unfortunate example of the disposition predominant among undistinguishing theorists to class together all the appearances which are observed at the same time, and in the immediate neighbourhood of each other. At that period, chemical phenomena were referred to mechanical principles; vegetable and animal life were subjected to mechanical or chemical laws; and while some physiologists[4] ascribed the vital functions to the understanding, the greater part of metaphysicians were disposed, with a grosser confusion, to derive the intellectual operations from bodily causes. The error in the latter case, though less immediately perceptible, is deeper and more fundamental than in any other; since it overlooks the primordial and perpetual distinction between *the being which thinks* and *the thing which is thought of*;—not to be lost sight of, by the mind's eye, even for a twinkling, without involving all nature in darkness and confusion.

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[1] The following sentences will illustrate the text, and are in truth applicable to all moral theories on merely intellectual principles:—"Reason alone, did we possess it in a higher degree, would answer all the ends of the passions. Thus there would be no need of parental affection, were all parents sufficiently acquainted with the reasons for taking upon them the guidance and support of those whom nature has placed under their care, *and were they virtuous enough to be always determined by those reasons*." (PRICE'S *Review*, 121.) A very slight consideration will show, that without the last words the preceding part would be utterly false, and with them it is utterly insignificant.

[2] Born in 1705; died in 1757.

[3] London, 1749.

[4] G. E. STAHL, born in 1660; died in 1734; a German physician and chemist of deserved eminence.

Hartley and Condillac,[1] who, much about the same time, but seemingly without any knowledge of each other's speculations,[2] began in a very similar mode to simplify, but also to mutilate the system of Locke, stopped short of what is called Materialism, which consummates the confusion, but touched its threshold. Thither, it must be owned, their philosophy pointed, and thither their followers proceeded. Hartley and Bonnet,[3] still more than Condillac, suffered themselves, like most of their contemporaries, to overlook the important truth, that all the changes in the organs which can be likened to other material phenomena, are nothing more than *antecedents and prerequisites of perception*, bearing not the faintest likeness to it; as much *outward* in relation to the thinking principle, as if they occurred in any other part of matter; and of which the entire comprehension, if it were attained, would not bring us a step nearer to the nature of thought. They who would have been the first to exclaim against the mistake of a sound for a colour, fell into the more unspeakable error of confounding the perception of objects, as outward, with the consciousness of our own mental operations. Locke's doctrine, that Reflection was a separate source of ideas, left room for this greatest of all distinctions,—though with much unhappiness of expression, and with no little variance from the course of his own speculations. Hartley, Condillac, and Bonnet, in hewing away this seeming deformity from the system of their master, unwittingly struck off the part of the building which, however unsightly, gave it the power of yielding some shelter and guard to truths, of which the exclusion rendered it utterly untenable. They became consistent Nominalists; a controversy on which Locke expresses himself with confusion and contradiction; but on this subject they added nothing to what had been taught by Hobbes and Berkeley. Both Hartley and Condillac[4] have the merit of having been unseduced by the temptations either of scepticism or of useless idealism; which, even if Berkeley and Hume could have been unknown to them, must have been within sight. Both agree in referring all the intellectual operations to the *association of ideas*, and in representing that association as reducible to the single law, that ideas which enter the mind at the same time, acquire a tendency to call up each other, which is in direct proportion to the frequency of their having entered together. In this important part of their doctrine they seem, whether unconsciously or otherwise, to have only repeated, and very much expanded, the opinion of Hobbes.[5] In its simplicity it is more agreeable than the system of Mr Hume, who admitted five independent laws of association; and it is in comprehension far superior to the views of the same subject by Mr Locke, whose ill-chosen name still retains its place in our nomenclature, but who only appeals to the principle as explaining some fancies and whimsies of the human mind. The capital fault of Hartley is that of a rash generalization, which may prove imperfect, and which is at least premature. All attempts to explain instinct by this principle have hitherto been unavailing. Many of the most important processes of reasoning have not hitherto been accounted for by it.[6] It would appear by a close examination, that even this theory, simple as it appears, *presupposes* many facts relating to the mind, of which its authors do not seem to have suspected the existence. How many ultimate facts of that nature, for example, are contained and involved in Aristotle's celebrated comparison of the mind in its first state to a sheet of unwritten paper![1] The texture of the paper, even its colour, the sort of instrument fit to act on it, its capacity to receive and to retain impressions, all its differences, from steel on the one hand to water on the other, certainly presuppose some facts, and may imply many, without a distinct statement of which, the nature of writing could not be explained to a person wholly ignorant of it. How many more, as well as greater laws, may be necessary to enable mind to perceive outward objects! If the power of perception may be thus dependent, why may not what is called the association of ideas, the attraction between thoughts, the power of one to suggest another, be affected by mental laws hitherto unexplored, perhaps unobserved?

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[1] Born in 1715; died in 1780.

[2] *Traité sur l'Origine des Connoissances Humaines*, 1746; *Traité des Systèmes*, 1749; *Traité des Sensations*, 1754. Foreign books were then little and slowly known in England. Hartley's reading, except on theology, seems confined to the physical and mathematical sciences; and his whole manner of thinking and writing is so different from that of Condillac, that there is not the least reason to suppose the work of the one to have been known to the other.

The work of Hartley, as we learn from the sketch of his life by his son, prefixed to the edition of 1791, was begun in 1730, and finished in 1746.

[3] Born in 1720; died in 1793.

[4] The following note of Condillac will show how much he differed from Hartley in his mode of considering the Newtonian hypothesis of vibrations, and how far he was in that respect superior to him. "Je suppose ici et ailleurs que les perceptions de l'âme ont pour cause physique l'ébranlement des fibres du cerveau; *non que je regarde cette hypothese comme démontrée, mais parcequ' elle est la plus commode pour expliquer ma pensée.*" (*Œuvres de* Condillac, I. 60. Paris, 1798.)

[5] *Human Nature*, chap. iv. v. vi. For more ancient statements, see Notes and Illustrations, note T.

[6] "Ce que les logiciens ont dit des raisonnements dans bien des volumes, me paroit entièrement superflu, et de nul usage" (Condillac, I. 115); an assertion of which the gross absurdity will be apparent to the readers of Dr Whately's *Treatise on Logic*, one of the most important works of the present age.

But to return from digression into the intellectual part of man: It becomes proper to say, that the difference between Hartley and Condillac, and the immeasurable superiority of the former, are chiefly to be found in the application which Hartley first made of the law of association to that other unnamed portion of our nature with which morality more immediately deals; that which feels pain and pleasure, is influenced by appetites and loathings, by desires and aversions, by affections and repugnances. Condillac's *Treatise on Sensation*, published five years after the work of Hartley, reproduces the doctrine of Hobbes with its root, namely, that love and hope are but transformed sensations,[2] by which he means perceptions of the senses; and its wide-spread branches, consisting in desires and passions, which are only modifications of self-love. "The words *goodness* and *beauty*," says he, almost in the very words of Hobbes, "express those qualities of things by which they contribute to our pleasures."[3] In the whole of his philosophical works, we find no trace of any desire produced by association, of any disinterested principle, or indeed of any distinction between the percipient and what, perhaps, we may now venture to call the *emotive* or the *pathematic* part of human nature, until some more convenient and agreeable name shall be hit on by some luckier or more skilful adventurer, in such new terms as seem to be absolutely necessary.

To the ingenuous, humble, and anxiously conscientious character of Hartley, we owe the knowledge that, about the year 1730, he was informed that the Rev. Mr Gay of Sidney College, Cambridge, then living in the west of England, asserted the possibility of deducing all our intellectual pleasures and pains from association; that this led him (Hartley) to consider the power of association; and that about that time Mr Gay published his sentiments on this matter in a dissertation prefixed to Bishop Law's Translation of King's *Origin of Evil.*[4] No writer deserves more the praise of abundant fairness than Hartley in this avowal. The dissertation of which he speaks is mentioned by no philosopher but himself. It suggested nothing apparently to any other reader. The general texture of it is that of homespun selfishness. The writer had the merit to see and to own that Hutcheson had established as a fact the reality of moral sentiments and disinterested affections. He blames, perhaps justly, that most ingenious man,[5] for assuming that these sentiments and affections are implanted, and partake of the nature of instincts. The object of his dissertation is to reconcile the mental appearances described by Hutcheson with the first principle of the selfish system, that "the true principle of all our actions is our own happiness." Moral feelings and social affections are, according to him, "resolvable into reason, pointing out our private happiness; and *whenever this end is not perceived*, they are to be accounted for from the association of ideas." Even in the single passage in which he shows a glimpse of the truth, he begins with confusion, advances with hesitation, and after holding in his grasp for an instant the principle which sheds so strong a light around it, suddenly drops it from his hand. Instead of receiving the statements of Hutcheson (his silence relating to Butler is unaccountable) as enlargements of the science of man, he deals with them merely as difficulties to be reconciled with the received system of universal selfishness. In the conclusion of his fourth section, he well exemplifies the power of association in forming the love of money, of fame, of power, &c.; but he still treats these effects of association as aberrations and infirmities, the fruits of our forgetfulness and shortsightedness, and not at all as the great process employed to sow and rear the most important principles of a social and moral nature.

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[1] See Notes and Illustrations, note U.

[2] CONDILLAC, III. 21; more especially *Traité des Sensations*, part ii. chap. vi. "Its love for outward objects is only an effect of love for itself."

[3] *Traité des Sensations*, part iv. chap. iii.

[4] Hartley's Preface to the *Observations on Man.* The word *intellectual* is too narrow. Even *mental* would be of very doubtful propriety. The theory in its full extent requires a word such as *inorganic*, (if no better can be discovered) extending to all gratification, not distinctly referred to some specific organ, or at least to some assignable part of the bodily frame.

[5] It has not been mentioned in its proper place, that Hutcheson appears nowhere to greater advantage than in Letters on the *Fable of the Bees*, published when he was very young, at Dublin, in a publication called *Hibernicus.* "Private vices public benefits," says he, "may signify any one of these five distinct propositions: 1. They are in themselves public benefits; or, 2. They naturally produce public happiness; or, 3. They may be made to produce it; or, 4. They may naturally flow from it; or, 5. At least they may probably flow from it in our infirm nature." (See a small volume containing *Thoughts on Laughter*, and *Observations on the Fable of the Bees*, Glasgow, 1758, in which these letters are republished.)

This precious mine may therefore be truly said to have been opened by Hartley; for he who did such superabundant justice to the hints of Gay, would assuredly not have withheld the like tribute from Hutcheson, had he observed the happy expression of "secondary passions," which ought to have led that philosopher himself farther than he ventured to advance. The extraordinary value of this part of Hartley's system has been hidden by various causes, which have also enabled writers who borrow from it to decry it. The influence of his medical habits renders many of his examples displeasing, and sometimes disgusting. He has none of that knowledge of the world, of that familiarity with literature, of that delicate perception of the beauties of nature and art, which not only supply the most agreeable illustrations of mental philosophy, but afford the most obvious and striking instances of its happy application to subjects generally interesting. His particular applications of the general law are often mistaken, and seldom more than brief notes and hasty suggestions; the germs of theories which, while some might adopt them without detection, others might discover without being aware that they were anticipated. To which it may be added, that in spite of the imposing forms of geometry, the work is not really distinguished by good method, or even uniform adherence to that which had been chosen. His style is entitled to no praise but that of clearness, and a simplicity of diction, through which is visible a singular simplicity of mind. No book perhaps exists which, with so few of the common allurements, comes at last so much to please by the picture it presents of the writer's character,—a character which kept him pure from the pursuit, often from the consciousness of novelty, and rendered him a discoverer in spite of his own modesty. In those singular passages in which, amidst the profound internal tranquillity of all the European nations, he foretells approaching convulsions, to be followed by the overthrow of states and churches, his quiet and gentle spirit, elsewhere almost ready to inculcate passive obedience for the sake of peace, is supported under its awful forebodings by the hope of that general progress in virtue and happiness which he saw through the preparatory confusion. A meek piety, inclining towards mysticism, and sometimes indulging in visions which borrow a lustre from his fervid benevolence, was beautifully, and perhaps singularly, blended in him with zeal for the most unbounded freedom of inquiry, flowing both from his own conscientious belief and his unmingled love of truth. Whoever can so far subdue his repugnance to petty or secondary faults as to bestow a careful perusal on the work, must be unfortunate if he does not see, feel, and own, that the writer was a great philosopher and a good man.

To those who thus study the work, it will be apparent that Hartley, like other philosophers, either overlooked, or failed explicitly to announce, that distinction between perception and emotion, without which no system of mental philosophy is complete. Hence arose the partial and incomplete view of truth conveyed by the use of the phrase "association of ideas." If the word *association*, which rather indicates the connection between separate things, than the perfect combination and fusion which occur in many operations of the mind, must, notwithstanding its inadequacy, still be retained, the phrase ought at least to be "association of thoughts with emotions, as well as with each other." With that enlargement an objection to the Hartleian doctrine would have been avoided, and its originality, as well as superiority over that of Condillac, would have appeared indisputable. The examples of avarice and other factitious passions are very well chosen; first, because few will be found to suppose that they are original principles of human nature;[1] secondly, because the process by which they are generated, being subsequent to the age of attention and recollection, may be brought home to the understanding of all men; and, thirdly, because they afford the most striking instance of secondary passions, which not only become independent of the primary principles from which they are derived, but hostile to them, and so superior in strength as to be capable of overpowering their parents. As soon as the mind becomes familiar with the frequent case of the man who first pursued money to purchase pleasure, but at last, when he becomes a miser, loves his hoard better than all that it could purchase, and sacrifices all pleasures for its increase, we are prepared to admit that, by a like process, the affections, when they are fixed on the happiness of others as their ultimate object, without any reflection on self, may not only be perfectly detached from self-regard or private desires, but may subdue these, and every other antagonist passion which can stand in their way. As the miser loves money for its own sake, so may the benevolent man delight in the wellbeing of his fellows. His good-will becomes as disinterested as if it had been implanted and underived. The like process applied to what is called self-love, or the desire of permanent wellbeing, clearly explains the mode in which that principle is gradually formed from the separate appetites, without whose previous existence no notion of wellbeing could be obtained. In like manner, sympathy, perhaps itself the result of a transfer of our own personal feelings by association to other sentient beings, and of a subsequent transfer of their feelings to our own minds, engenders the various social affections, which at last generate in most minds some regard to the wellbeing of our country, of mankind, of all creatures capable of pleasure. Rational self-love controls and guides those far keener self-regarding passions of which it is the child, in the same manner as general benevolence balances and governs the variety of much warmer social affections from which it springs. It is an ancient and obstinate error of philosophers to represent these two calm principles as being the source of the impelling passions and affections, instead of being among the last results of them. Each of them exercises a sort of authority in its sphere, but the dominion of neither is co-existent with the whole nature of man. Though they have the power to quicken and check, they are both too feeble to impel; and if the primary principles were extinguished, they would both perish from want of nourishment. If indeed all appetites and desires were destroyed, no subject would exist on which either of these general principles could act.

The affections, desires, and emotions, having for their ultimate object the dispositions and actions of voluntary agents, which alone, from the nature of their object, are co-extensive with the whole of our active nature, are, according to the same philosophy, necessarily formed in every human mind by the transfer of feeling which is effected by the principle of association. Gratitude, pity, resentment, and shame, seem to be the simplest, the most active, and the most uniform elements in their composition.

It is easy to perceive how the complacency inspired by a benefit may be transferred to a benefactor, thence to all beneficent beings and acts. The well-chosen instance of the nurse familiarly exemplifies the manner in which the child transfers his complacency from the gratification of his senses to the cause of it, and thus learns an affection for her who is the source of his enjoyment. With this simple process concur, in the case of a tender nurse, and far more of a mother, a thousand acts of relief and endearment, of which the complacency is fixed on the person from whom they flow, and in some degree extended by association to all who resemble that person. So much of the pleasure of early life depends on others, that the like process is almost constantly repeated. Hence the origin of benevolence may be understood, and the disposition to approve all benevolent, and disapprove all malevolent acts. Hence also the same approbation and disapprobation are extended to all acts which we clearly perceive to promote or obstruct the happiness of men. When the complacency is extended to action, benevolence may be said to be transformed into a part of conscience. The rise of sympathy may probably be explained by the process of association, which transfers the feelings of others to ourselves, and ascribes our own feelings to others;—at first, and in some degree, always in proportion as the resemblance of ourselves to others is complete. The likeness in the outward signs of emotion is one of the widest channels in this commerce of hearts. Pity thereby becomes one of the grand sources of benevolence, and perhaps contributes more largely than gratitude. It is indeed one of the first motives to the conferring of those benefits which inspire grateful affection. Sympathy with the sufferer, therefore, is also transformed into a real sentiment, directly approving benevolent actions and dispositions, and more remotely all actions that promote happiness. The anger of the sufferer, first against all causes of pain, afterwards against all intentional agents who produce it, and finally against all those in whom the infliction of pain proceeds from a mischievous disposition, when it is communicated to others by sympathy, and is so far purified by gradual separation from selfish and individual interest as to be equally felt against all wrong-doers, whether the wrong be done against ourselves, our friends, or our enemies, is the root out of which springs that which is commonly and well called a *Sense of Justice*—the most indispensable, perhaps, of all the component parts of the moral faculties. It is the main guard against wrong. It relates to that portion of morality where many of the outward acts are capable of being reduced under certain rules, of which the violations, wherever the rule is sufficiently precise, and the mischief sufficiently great, may be guarded against by the terror of punishment. In the observation of the rules of justice consists *duty;* breaches of them we denominate *crimes.* An abhorrence of crimes, especially of those which indicate the absence of benevolence, as well as of regard to justice, is peculiarly strong; because well-framed penal laws, being the lasting declaration of the moral indignation of many generations of mankind, exceedingly strengthen the same feeling in every individual, as long as they remain in unison with the sentiments of the age and country for which they are destined, and, indeed, wherever the laws do not so much deviate from the habitual feelings as to produce a struggle between law and sentiment, in which it is hard to say on which side success is most deplorable. A man who performs his duties may be esteemed, but is not admired; because it requires no more than ordinary virtue to act well where it is shameful and dangerous to do otherwise. The righteousness of those who act solely from such inferior motives, is little better than that "of the Scribes and Pharisees." Those only are just in the eye of the moralist who act justly from a constant disposition to render to every man his own.[1] Acts of kindness, of generosity, of pity, of placability, of humanity, when they are long continued, can hardly fail mainly to flow from the pure fountain of an excellent nature. They are not reducible to rules; and the attempt to enforce them by punishment would destroy them. They are *virtues* of which the essence consists in a good disposition of mind. As we gradually transfer our desire from praise to praiseworthiness, this principle also is adopted into consciousness. On the other hand, when we are led by association to feel a painful contempt for those feelings and actions of our past self which we despise in others, there is developed in our hearts another element of that moral sense. It is a remarkable instance of the power of the law of association, that the contempt or abhorrence which we feel for the bad actions of others may be transferred by it, in any degree of strength, to our own past actions of the like kind. And as the hatred of bad actions is transferred to the agent, the same transfer may occur in our own case in a manner perfectly similar to that of which we are conscious in our feelings towards our fellow-creatures. There are many causes which render it generally feebler; but it is perfectly evident that it requires no more than a sufficient strength of moral feeling to make it equal; and that the most apparently hyperbolical language used by penitents, in describing their *remorse*, may be justified by the principle of association.

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[1] A very ingenious man, Lord Kames, whose works had a great effect in rousing the mind of his contemporaries and countrymen, has indeed fancied that there is "a hoarding instinct" in man and other animals. But such conclusions are not so much objects of confutation, as ludicrous proofs of the absurdity of the premises which lead to them.

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[1] "Justitia est constans et perpetua voluntas suum cuique tribuendi;" an excellent definition in the mouth of the Stoical moralists, from whom it is borrowed, but altogether misplaced by the Roman Jurists in a body of laws which deal only with outward acts in their relation to the order and interest of society.

At this step in our progress, it is proper to observe, that a most important consideration has escaped Hartley, as well as every other philosopher.[1] The language of all mankind implies that the moral faculty, whatever it may be, and from what origin soever it may spring, is intelligibly and properly spoken of as ONE. It is as common in mind as in matter for a compound to have properties not to be found in any of its constituent parts. The truth of this proposition is as certain in the human feelings as in any material combination. It is therefore easily understood, that originally separate feelings may be so perfectly blended by a process performed in every mind, that they can no longer be disjoined from each other, but must always co-operate, and thus reach the only union which we can conceive. The sentiment of *Moral Approbation*, formed by association out of antecedent affections, may become so perfectly independent of them, that we are no longer conscious of the means by which it was formed, and never can in practice repeat, though we may in theory perceive, the process by which it was generated. It is in that mature and sound state of our nature that our emotions at the view of *Right* and *Wrong* are ascribed to *Conscience*. But why, it may be asked, do these feelings, rather than others, run into each other, and constitute Conscience? The answer seems to be what has already been intimated in the observations on Butler. The affinity between these feelings consists in this, that while all other feelings relate to outward objects, they alone contemplate exclusively the *dispositions and actions of voluntary agents*. When they are completely transferred from objects, and even persons, to dispositions and actions, they are fitted, by the perfect coincidence of their *aim*, for combining to form that one faculty which is directed only to that *aim*.

The words *Duty* and *Virtue*, and the word *Ought*, which most perfectly denotes *Duty*, but is also connected with *Virtue*, in every well-constituted mind, in this state become the fit language of the acquired, perhaps, but universally and necessarily acquired, faculty of Conscience. Some account of its peculiar nature has been attempted in the remarks on Butler;—for others a fitter occasion will occur hereafter. Some light may however now be thrown on the subject by a short statement of the hitherto unobserved distinction between the moral sentiments and another class of feelings with which they have some qualities in common. The pleasures (so called) of Imagination appear, at least in most cases, to originate in association. But it is not till the original cause of the gratification is obliterated from the mind, that they acquire their proper character. Order and proportion may be at first chosen for their convenience: it is not until they are admired for their own sake that they become objects of taste. Though all the proportions for which a horse is valued may be indications of speed, safety, strength, and health, it is not the less true that they only can be said to admire the animal for his beauty, who leave such considerations out of the account while they admire. The pleasure of contemplation in these particulars of nature and art becomes universal and immediate, being entirely detached from all regard to individual beings. It contemplates neither use nor interest.

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[1] See *supra*, section on Butler.

In this important particular the pleasures of imagination agree with the moral sentiments. Hence the application of the same language to both in ancient and modern times. Hence also it arises that they may contemplate the very same qualities and objects. There is certainly much beauty in the softer virtues—much grandeur in the soul of a Hero or a Martyr. But the essential distinction still remains. The purest moral taste contemplates these qualities only with *quiescent* delight or reverence. It has no further view;—it points towards no action. Conscience, on the contrary, containing in it a pleasure in the prospect of doing right, and an ardent desire to act well, having for its sole object the dispositions and acts of voluntary agents, is not, like moral taste, satisfied with passive contemplation, but constantly tends to act on the will and conduct of the man. Moral taste may aid it, may be absorbed into it, and usually contributes its part to the formation of the moral faculty; but it is distinct from that faculty, and may be disproportioned to it. Conscience, being by its nature confined to mental dispositions and voluntary acts, is of necessity excluded from the ordinary consideration of all things antecedent to these dispositions. The circumstances from which such states of mind may arise, are most important objects of consideration for the understanding; but they are without the sphere of conscience, which never ascends beyond the heart of the man. It is thus that in the eye of conscience man becomes amenable to its authority for all his inclinations as well as deeds; that some of them are approved, loved, and revered; and that all the outward effects of disesteem, contempt, or moral anger, are felt to be the just lot of others.

But, to return to Hartley, from this perhaps intrusive statement of what does not properly belong to him: He represents all the social affections of gratitude, veneration, and love, inspired by the virtues of our fellow-men, as capable of being transferred by association to the transcendent and unmingled goodness of the Ruler of the world, and thus to give rise to piety, to which he gives the name of the theopathetic affection. This principle, like all the former in the mental series, is gradually detached from the trunk on which it grew: it takes separate root, and may altogether overshadow the parent stock. As such a being cannot be conceived without the most perfect and constant reference to his goodness, so piety may not only become a part of conscience, but its governing and animating principle, which, after long lending its own energy and authority to every other, is at last described by our philosopher as swallowing up all of them in order to perform the same functions more infallibly.

In every stage of this progress we are taught by Dr Hartley that a new product appears, which becomes perfectly distinct from the elements which formed it, which may be utterly dissimilar to them, and may attain any degree of vigour, however superior to theirs. Thus the objects of the private desires disappear when we are employed in the pursuit of our lasting welfare; that which was first sought only as a means, may come to be pursued as an end, and preferred to the original end; the good opinion of our fellows becomes more valued than the benefits for which it was at first courted; a man is ready to sacrifice his life for him who has shown generosity, even to others; and persons otherwise of common character are capable of cheerfully marching in a forlorn hope, or of almost instinctively leaping into the sea to save the life of an entire stranger. These last acts, often of almost unconscious virtue, so familiar to the soldier and the sailor, so unaccountable on certain systems of philosophy, often occur without a thought of applause and reward; too quickly for the thought of the latter, too obscurely for the hope of the former; and they are of such a nature that no man could be impelled to them by the mere expectation of either.

The gratitude, sympathy, resentment, and shame, which are the principal constituent parts of the Moral Sense, thus lose their separate agency, and constitute an entirely new faculty, co-extensive with all the dispositions and actions of voluntary agents; though some of them are more predominant in particular cases of moral sentiment than others, and though the aid of all continues to be necessary in their original character, as subordinate but distinct motives of action. Nothing more evidently points out the distinction of the Hartleian system from all systems called selfish, not to say its superiority in respect to disinterestedness over all moral systems before Butler and Hutcheson, than that excellent part of it which relates to the Rule of Life. The various principles of human action rise in value according to the order in which they spring up after each other. We can then only be in a state of as much enjoyment as we are evidently capable of attaining, when we prefer interest to the original gratifications—honour to interest—the pleasures of imagination to those of sense—the dictates of conscience to pleasure, interest, and reputation—the well-being of fellow-creatures to our own indulgences; in a word, when we pursue moral good and social happiness chiefly and for their own sake. "With self-interest," says Hartley, somewhat inaccurately in language, "man must begin. He may end in self-annihilation. Theopathy, or piety, although the last result of the purified and exalted sentiments, may at length swallow up every other principle, and absorb the whole man." Even if this last doctrine should be an exaggeration unsuited to our present condition, it will the more strongly illustrate the compatibility, or rather the necessary connection, of this theory with the existence and power of perfectly disinterested principles of human action.

It is needless to remark on the *secondary* and *auxiliary* causes which contribute to the formation of moral sentiment; education, imitation, general opinion, laws and government. They all presuppose the moral faculty: in an improved state of society they contribute powerfully to strengthen it, and on some occasions they enfeeble, distort, and maim it; but in all cases they must themselves be tried by the test of an ethical standard.

The value of this doctrine will not be essentially affected by supposing a greater number of original principles than those assumed by Dr Hartley. The principle of association applies as much to a greater as to a smaller number. It is a quality common to it with all theories, that the more simplicity it reaches consistently with truth, the more perfect it becomes. Causes are not to be multiplied without necessity. If by a considerable multiplication of primary desires the law of association were lowered nearly to the level of an auxiliary agent, the philosophy of human nature would still be under indelible obligations to the philosopher who, by his fortunate error, rendered the importance of that great principle obvious and conspicuous.

ABRAHAM TUCKER.[1]

It has been the remarkable fortune of this writer to have been more prized by the cultivators of the same subjects, and more disregarded by the generality even of those who read books on such matters, than perhaps any other philosopher.[2] He had many of the qualities which might be expected in an affluent country gentleman, living in a privacy undisturbed by political zeal, and with a leisure unbroken by the calls of a profession, at a time when England had not entirely renounced her old taste for metaphysical speculation. He was naturally endowed, not indeed with more than ordinary acuteness or sensibility, nor with a high degree of reach and range of mind, but with a singular capacity for careful observation and original reflection, and with a fancy perhaps unmatched in producing various and happy illustration. The most observable of his moral qualities appear to have been prudence and cheerfulness, good-nature and easy temper. The influence of his situation and character is visible in his writings. Indulging his own tastes and fancies, like most English squires of his time, he became, like many of them, a sort of humourist. Hence much of his originality and independence; hence the boldness with which he openly employs illustrations from homely objects. He wrote to please himself more than the public. He had too little regard for readers, either to sacrifice his sincerity to them, or to curb his own prolixity, repetition, and egotism, from the fear of fatiguing them. Hence he became as loose, as rambling, and as much an egotist as Montaigne; but not so agreeably so, notwithstanding a considerable resemblance of genius; because he wrote on subjects where disorder and egotism are unseasonable, and for readers whom they disturb instead of amusing. His prolixity at last increased itself, when his work became so long, that repetition in the latter parts partly arose from forgetfulness of the former; and though his freedom from slavish deference to general opinion is very commendable, it must be owned, that his want of a wholesome fear of the public renders the perusal of a work which is extremely interesting, and even amusing in most of its parts, on the whole a laborious task. He was by early education a believer in Christianity, if not by natural character religious. His calm good sense and accommodating temper led him rather to explain established doctrines in a manner agreeable to his philosophy, than to assail them. Hence he was represented as a time-server by free-thinkers, and as a heretic by the orthodox.[1] Living in a country where the secure tranquillity flowing from the Revolution was gradually drawing forth all mental activity towards practical pursuits and outward objects, he hastened from the rudiments of mental and moral philosophy, to those branches of it which touch the business of men.[2] Had he recast without changing his thoughts,—had he detached those ethical observations for which he had so peculiar a vocation, from the disputes of his country and his day,—he might have thrown many of his chapters into their proper form of essays, which might have been compared, though not likened, to those of Hume. But the country gentleman, philosophic as he was, had too much fondness for his own humours to engage in a course of drudgery and deference. It may, however, be confidently added, on the authority of all those who have fairly made the experiment, that whoever, unfettered by a previous system, undertakes the labour necessary to discover and relish the high excellencies of this metaphysical Montaigne, will find his toil lightened as he proceeds, by a growing indulgence, if not partiality, for the foibles of the humourist; and at last rewarded, in a greater degree perhaps than by any other writer on mixed and applied philosophy, by being led to commanding stations and new points of view, whence the mind of a moralist can hardly fail to catch some fresh prospects of nature and duty.

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[1] Born in 1705; died in 1774.

[2] "I have found in this writer more original thinking and observation upon the several subjects that he has taken in hand than in any other, not to say than in all others put together. His talent also for illustration is unrivalled." (PALEY, Preface to *Moral and Political Philosophy.*) See the excellent preface to an abridgement, by Mr Hazlitt, of Tucker's work, published in London in 1807. May I venture to refer also to my own discourse on the *Law of Nature and Nations*, London, 1799. Mr Stewart treats Tucker and Hartley with unwonted harshness.

It is in mixed, not in pure philosophy, that his superiority consists. In the part of his work which relates to the intellect, he has adopted much from Hartley, hiding but aggravating the offence by a change of technical terms; and he was ungrateful enough to countenance the vulgar sneer which involves the mental analysis of that philosopher in the ridicule to which his physiological hypothesis is liable.[3] Thus, for the Hartleian term *Association* he substitutes that of *Translation*, when he adopts the same theory of the principles which move the mind to action. In the practical and applicable part of that inquiry he indeed far surpasses Hartley; and it is little to add, that he unspeakably exceeds that bare and naked thinker in the useful as well as admirable faculty of illustration. In the strictly theoretical part his exposition is considerably fuller; but the defect of his genius becomes conspicuous when he handles a very general principle. The very term *Translation* ought to have kept up in his mind a steady conviction that the secondary motives to action become as independent, and seek their own objects as exclusively, as the primary principles. His own examples are rich in proofs of this important truth. But there is a slippery descent in the Theory of Human Nature, by which he, like most of his forerunners, slid unawares into selfishness. He was not preserved from this fall by seeing that all the deliberate principles which have self for their object are themselves of *secondary formation;* and he was led to the general error by the notion that Pleasure, or, as he calls it, Satisfaction, was the original and sole object of all appetites and desires; confounding this with the true but very different proposition, that the attainment of all the objects of appetite and desire is productive of pleasure. He did not see that, without presupposing Desires, the word Pleasure would have no signification; and that the representations by which he was seduced would leave only *one appetite* or *desire* in human nature. He had no adequate and constant conception, that the translation of Desire from the end to the means occasioned the formation of a new passion, which is perfectly distinct from, and altogether independent of, the original desire. Too frequently (for he was neither obstinate nor uniform in error) he considered these translations as accidental defects in human nature, not as the appointed means of supplying it with its variety of active principles. He was too apt to speak as if the selfish elements were not destroyed in the new combination, but remained still capable of being recalled, when convenient, like the links in a chain of reasoning, which we pass over from forgetfulness, or for brevity. Take him all in all, however, the neglect of his writings is the strongest proof of the disinclination of the English nation, for the last half century, to Metaphysical Philosophy.[1]

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[1] This disposition to compromise and accommodation, which is discoverable in Paley, was carried to its utmost length by Mr Hey, a man of much acuteness, Professor of Divinity at Cambridge.

[2] Perhaps no philosopher ever stated more justly, more naturally, or more modestly than Tucker, the ruling maxim of his life. "My thoughts," says he, "have taken a turn from my earliest youth towards searching into the foundations and measures of right and wrong; my love for retirement has furnished me with continual leisure; and the exercise of my reason has been my daily employment."

[3] *Light of Nature*, I. c. xviii. of which the conclusion may be pointed out as a specimen of perhaps unmatched fruitfulness, vivacity, and felicity of illustration. The admirable sense of the conclusion of chap. xxv. seems to have suggested Paley's good chapter *on Happiness*. The alteration of Plato's comparison of reason to a charioteer, and the passions to the horses, in chap. xxvi. is of characteristic and transcendent excellence.

WILLIAM PALEY.[2]

This excellent writer, who, after Clarke and Butler, ought to be ranked among the brightest ornaments of the English church in the eighteenth century, is, in the history of philosophy, naturally placed after Tucker, to whom, with praiseworthy liberality, he owns his extensive obligations. It is a mistake to suppose that he owed his system to Hume, a thinker too refined, and a writer perhaps too elegant, to have naturally attracted him. A coincidence in the principle of utility, common to both with so many other philosophers, affords no sufficient ground for the supposition. Had he been habitually influenced by Mr Hume, who has translated so many of the dark and crabbed passages of Butler into his own transparent as well as beautiful language, it is not possible to suppose that such a mind as that of Paley should have fallen into those principles of gross selfishness of which Mr Hume is a uniform and zealous antagonist.

The natural frame of Paley's understanding fitted it more for business and the world than for philosophy; and he accordingly enjoyed with considerable relish the few opportunities which the latter part of his life afforded of taking a part in the affairs of his county as a magistrate. Penetration and shrewdness, firmness and coolness, a vein of pleasantry, fruitful though somewhat unrefined, with an original homeliness and significancy of expression, were perhaps more remarkable in his conversation than the restraints of authorship and profession allowed them to be in his writings. Grateful remembrance brings this assemblage of qualities with unfaded colours before the mind at the present moment, after the long interval of twenty-eight years. His taste for the common business and ordinary amusements of life fortunately gave a zest to the company which his neighbourhood chanced to yield, without rendering him insensible to the pleasures of intercourse with more enlightened society. The practical bent of his nature is visible in the language of his writings, which, on practical matters, is as precise as the nature of the subject requires, but, in his rare and reluctant efforts to rise to first principles, becomes indeterminate and unsatisfactory; though no man's composition was more free from the impediments which hinder a writer's meaning from being quickly and clearly seen. He seldom distinguishes more exactly than is required for palpable and direct usefulness. He possessed that chastised acuteness of discrimination, exercised on the affairs of men, and habitually looking to a purpose beyond the mere increase of knowledge, which forms the character of a lawyer's understanding, and which is apt to render a mere lawyer too subtile for the management of affairs, and yet too gross for the pursuit of general truth. His style is as near perfection in its kind as any in our language. Perhaps no words were ever more expressive and illustrative than those in which he represents the art of life to be that of rightly "setting our habits."

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[1] Much of Tucker's chapter *on Pleasure*, and of Paley's *on Happiness* (both of which are invaluable), is contained in the passage of *The Traveller*, of which the following couplet expresses the main object:

" Unknown to them when sensual pleasures cloy,
" To fill the languid pause with finer joy."

" An honest man," says Mr Hume, " has the frequent satisfaction of seeing knaves betrayed by their own maxims." (*Enquiry into Morals.*)

" I used often to laugh at your honest simple neighbour Flamborough, and one way or another generally cheated him once a year. Yet still the honest man went forward without suspicion, and grew rich, while I still continued tricksy and cunning, and was poor, without the consolation of being honest." (*Vicar of Wakefield*, chap. xxvi.)

[2] Born in 1743; died in 1805.

The most original and ingenious of his writings is the *Horæ Paulinæ*. The *Evidences of Christianity* are formed out of an admirable translation of Butler's *Analogy*, and a most skilful abridgement of Lardner's *Credibility of the Gospel History*. He may be said to have thus given value to two works, of which the first was scarcely intelligible to most of those who were most desirous of profiting by it; and the second soon wearies out the greater part of readers, though the few who are more patient have almost always been gradually won over to feel pleasure in a display of knowledge, probity, charity, and meekness, unmatched by an avowed advocate in a case deeply interesting his warmest feelings. His *Natural Theology* is the wonderful work of a man who, after sixty, had studied anatomy in order to write it; and it could only have been surpassed by a man who, to great originality of conception and clearness of exposition, added the advantage of a high place in the first class of physiologists.[1]

It would be unreasonable here to say much of a work which is in the hands of so many as his *Moral and Political Philosophy*. A very few remarks on one or two parts of it may be sufficient to estimate his value as a moralist, and to show his defects as a metaphysician. His general account of virtue may indeed be chosen for both purposes. The manner in which he deduces the necessary tendency of all virtuous actions to the general happiness, from the goodness of the Divine Lawgiver, though the principle be not, as has already more than once appeared, peculiar to him, but rather common to most religious philosophers, is characterized by a clearness and vigour which have never been surpassed. It is indeed nearly, if not entirely, an identical proposition, that a Being of unmixed benevolence will prescribe those laws only to his creatures which contribute to their wellbeing. When we are convinced that a course of conduct is generally beneficial to all men, we cannot help considering it as acceptable to a benevolent Deity. The usefulness of actions is the mark set on them by the Supreme Legislator, by which reasonable beings discover it to be His will that such actions should be done. In this apparently unanswerable deduction it is partly admitted, and universally implied, that the principles of right and wrong may be treated apart from the manifestation of them in the Scriptures. If it were otherwise, how could men of perfectly different religions deal or reason with each other on moral subjects? How could they regard rights and duties as subsisting between them? To what common principles could they appeal in their differences? Even the Polytheists themselves, those worshippers of

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[1] See *Animal Mechanics*, by Mr Charles Bell, published by the Society for Useful Knowledge.

> Gods partial, changeful, passionate, unjust,
> Whose attributes are rage, revenge, or lust,

by a happy inconsistency are compelled, however irregularly and imperfectly, to ascribe some general enforcement of the moral code to their divinities. If there were no foundation for morality antecedent to revealed religion, we should want that important test of the conformity of a revelation to pure morality, by which its claim to a divine origin is to be tried. The internal evidence of religion necessarily presupposes such a standard. The Christian contrasts the precepts of the Koran with the pure and benevolent morality of the Gospel. The Mahometan claims, with justice, a superiority over the Hindoo, inasmuch as the Mussulman religion inculcates the moral perfection of one Supreme Ruler of the world. The ceremonial and exclusive character of Judaism has ever been regarded as an indication that it was intended to pave the way for a universal religion,—a morality seated in the heart, and a worship of sublime simplicity. These discussions would be impossible, unless morality were previously proved or granted to exist. Though the science of Ethics is thus far independent, it by no means follows that there is any equality, or that there may not be the utmost inequality, in the moral tendency of religious systems. The most ample scope is still left for the zeal and activity of those who seek to spread important truth. But it is absolutely essential to ethical science that it should contain principles, the authority of which must be recognised by men of every conceivable variety of religious opinion.

The peculiarities of Paley's mind are discoverable in the comparison, or rather contrast, between the practical chapter on Happiness, and the philosophical portion of the chapter on Virtue. "Virtue is the doing good to mankind, in obedience to the will of God, and for the sake of everlasting happiness."[1] It is not perhaps very important to observe, that these words, which he offers as "a definition," ought in propriety to have been called a proposition; but it is much more necessary to say that they contain a false account of virtue. According to this doctrine, every action not done *for the sake* of the agent's happiness is vicious. Now, it is plain that an act cannot be said to be done for the sake of any thing which is not present to the mind of the agent at the moment of action. It is a contradiction in terms to affirm that a man acts for the sake of any object, of which, however it may be the necessary consequence of his act, he is not at the time fully aware. The *unfelt* consequences of his act can no more influence his will than its *unknown* consequences. Nay, further, a man is only with any propriety said to act for the sake of his chief object; nor can he with entire correctness be said to act for the sake of any thing but his sole object. So that it is a necessary consequence of Paley's proposition, that every act which flows from generosity or benevolence is a vice. So also of every act of obedience to the will of God, if it arises from any motive but a desire of the reward which he will bestow. Any act of obedience influenced by gratitude, and affection, and veneration towards supreme benevolence and perfection, is so far imperfect; and if it arises solely from these motives it becomes a vice. It must be owned, that this excellent and most enlightened man has laid the foundations of religion and virtue in a more intense and exclusive selfishness than was avowed by the Catholic enemies of Fenelon, when they persecuted him for his doctrine of a pure and disinterested love of God.

In another province, of a very subordinate kind, the disposition of Paley to limit his principles to his own time and country, and to look at them merely as far as they are calculated to amend prevalent vices and errors, betrayed him into narrow and false views. His chapter on what he calls the *Law of Honour* is unjust, even in its own small sphere, because it supposes honour to *allow* what it does *not forbid;* though the truth be, that the vices enumerated by him are only not *forbidden* by honour, because they are not within its jurisdiction. He considers it as "a system of rules constructed by people of fashion;"—a confused and transient mode of expression, which may be understood with difficulty by our posterity, and which cannot now be exactly rendered perhaps in any other language.

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[1] Paley, book i. chap. vii.

The subject, however, thus narrowed and lowered, is neither unimportant in practice, nor unworthy of the consideration of the moral philosopher. Though all mankind honour virtue and despise vice, the degree of respect or contempt is often far from being proportioned to the place which virtues and vices occupy in a just system of Ethics. Wherever higher honour is bestowed on one moral quality than on others of equal or greater moral value, *what is called a point of honour may be said to exist.* It is singular that so shrewd an observer as Paley should not have observed a law of honour far more permanent than that which attracted his notice, in the feelings of Europe respecting the conduct of men and women. Cowardice is not so immoral as cruelty, nor indeed so detestable, but it is more despicable and disgraceful. The female point of honour forbids indeed a great vice, but one not so great as many others by which it is not violated. It is easy enough to see, that where we are strongly prompted to a virtue by a natural impulse, we love the man who is constantly actuated by the amiable sentiment, but we do not consider that which is done without difficulty as requiring or deserving admiration and distinction. The kind affections are their own rich reward, and they are the object of affection to others. To encourage kindness by praise would be to insult it, besides its effect in producing counterfeits. It is for the conquest of fear, it would be still more for the conquest of resentment, if that were not, wherever it is real, the cessation of a state of mental agony, that the applause of mankind is reserved. Observations of a similar nature will easily occur to every reader respecting the point of honour in the other sex. The conquest of natural frailties, especially in a case of far more importance to mankind than is at first sight obvious, is well distinguished as an object of honour, and the contrary vice is punished by shame. Honour is not wasted on those who abstain from acts which are punished by the law. These acts may be avoided without a pure motive. Wherever a virtue is easily performed by good men—wherever it is its nature to be attended by delight—wherever its outward observance is so necessary to society as to be enforced by punishment—it is not the proper object of honour. Honour and shame, therefore, may be reasonably dispensed, without being strictly proportioned to the intrinsic morality of actions, if the inequality of their distribution contributes to the general equipoise of the whole moral system.

A wide disproportion, however, or indeed any disproportion not justifiable on moral grounds, would be a depravation of the moral principle. Duelling is among us a disputed case, though the improvement of manners has rendered it so much more infrequent, that it is likely in time to lose its support from opinion. Those who excuse individuals for yielding to a false point of honour, as in the suicides of the Greeks and Romans, may consistently blame the faulty principle, and rejoice in its destruction. The shame fixed on a Hindoo widow of rank who voluntarily survives her husband, is regarded by all other nations with horror.

There is room for great praise and some blame in other parts of Paley's works. His political opinions were those generally adopted by moderate whigs in his own age. His language on the Revolution of 1688 may be very advantageously compared, both in precision and in generous boldness,[1] to that of Blackstone, a great master of classical and harmonious composition, but a feeble reasoner and a confused thinker, whose writings are not exempt from the taint of slavishness.

It cannot be denied that Paley was sometimes rather a lax moralist, especially on public duties.

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[1] "*Government may be too secure.* The greatest tyrants have been those whose titles were the most unquestioned. Whenever, therefore, the opinion of right becomes too predominant and superstitious, *it is abated by breaking the custom.* Thus the Revolution broke the custom of succession, and thereby moderated, both in the prince and in the people, those lofty notions of hereditary right, which in the one were become a continual incentive to tyranny, and disposed the other to invite servitude, by undue compliances and dangerous concessions." (PALEY, book vi. chap. ii.)

It is a sin which easily besets men of strong good sense, little enthusiasm, and much experience. They are naturally led to lower their precepts to the level of their expectations. They see that higher pretensions often produce less good, to say nothing of the hypocrisy, extravagance, and turbulence, to which they lend some colour. As those who claim more from men often gain less, it is natural for more sober and milder casuists to present a more accessible virtue to their followers. It was thus that the Jesuits began, till, strongly tempted by their perilous station as the moral guides of the powerful, some of them by degrees fell into that absolute licentiousness for which all, not without injustice, have been cruelly immortalized by Pascal. Indulgence, which is a great virtue in judgment concerning the actions of others, is too apt, when blended in the same system with the precepts of morality, to be received as a licence for our own offences. Accommodation, without which society would be painful, and arduous affairs would become impracticable, is more safely imbibed from temper and experience, than taught in early and systematic instruction. The middle region between laxity and rigour is hard to be fixed, and it is still harder steadily to remain within its boundaries. Whatever may be thought of Paley's observations on political influence and ecclesiastical subscription, as temperaments and mitigations which may preserve us from harsh judgment, they are assuredly not well qualified to form a part of that discipline which ought to breathe into the opening souls of youth, at the critical period of the formation of character, those inestimable virtues of sincerity, of integrity, of independence, which will even guide them *more safely* through life than mere prudence, while they provide an inward fountain of pure delight, immeasurably more abundant than all the outward sources of precarious and perishable pleasure.

JEREMY BENTHAM.

The general scheme of this Dissertation would be a sufficient reason for omitting the name of a living writer. The devoted attachment and invincible repugnance which an impartial estimate of Mr Bentham has to encounter on either side, are a strong inducement not to deviate from that scheme in his case. But the most brief sketch of ethical controversy in England would be imperfect without it; and perhaps the utter hopelessness of any expedient for satisfying his followers, or softening his opponents, may enable a writer to look steadily and solely at what he believes to be the dictates of truth and justice. He who has spoken of former philosophers with unreserved freedom, ought perhaps to subject his courage and honesty to the severest test by an attempt to characterize such a contemporary. Should the very few who are at once enlightened and unbiassed be of opinion that his firmness and equity have stood this trial, they will be the more disposed to trust his fairness where the exercise of that quality is more easy.

The disciples of Mr Bentham are more like the hearers of an Athenian philosopher than the pupils of a modern professor, or the cool proselytes of a modern writer. They are in general men of competent age, of superior understanding, who voluntarily embrace the laborious study of useful and noble sciences; who derive their opinions not so much from the cold perusal of his writings, as from familiar converse with a master from whose lips these opinions are recommended by simplicity, disinterestedness, originality, and vivacity; aided rather than impeded by foibles not unamiable, enforced of late by the growing authority of years and of fame, and at all times strengthened by that undoubting reliance on his own judgment which mightily increases the ascendant of such a man over those who approach him. As he and they deserve the credit of braving vulgar prejudices, so they must be content to incur the imputation of falling into the neighbouring vices of seeking distinction by singularity; of clinging to opinions because they are obnoxious; of wantonly wounding the most respectable feelings of mankind; of regarding an immense display of method and nomenclature as a sure token of a corresponding increase of knowledge; and of considering themselves as a chosen few, whom an initiation into the most secret mysteries of philosophy entitles to look down with pity, if not contempt, on the profane multitude. Viewed with aversion or dread by the public, they become more bound to each other and to their master; while they are provoked into the use of language which more and more exasperates opposition to them, A hermit in the greatest of cities, seeing only his disciples, and indignant that systems of government and law which he believes to be perfect are disregarded at once by the many and the powerful, Mr Bentham has at length been betrayed into the most unphilosophical hypothesis, that all the ruling bodies who guide the community have conspired to stifle and defeat his discoveries. He is too little acquainted with doubts to believe the honest doubts of others, and he is too angry to make allowance for their prejudices and habits. He has embraced the most extreme party in practical politics; manifesting more dislike and contempt towards those who are more moderate supporters of popular principles than towards their most inflexible opponents. To the unpopularity of his philosophical and political doctrines he has added the more general and lasting obloquy which arises from an unseemly treatment of doctrines and principles which, if there were no other motives for reverential deference, even a regard to the feelings of the best men requires to be approached with decorum and respect.

Fifty-three years have passed since the publication of Mr Bentham's first work, *A Fragment on Government*,—a considerable octavo volume, employed in the examination of a short paragraph of Blackstone,—unmatched in acute hypercriticism, but conducted with a severity which leads to an unjust estimate of the writer criticised, till the like experiment be repeated on other writings. It was a waste of extraordinary power to employ it in pointing out flaws and patches in the robe occasionally stolen from the philosophical schools, which hung loosely and unbecomingly on the elegant commentator. This volume, and especially the preface, abounds in fine, original, and just observation; it contains the germs of most of his subsequent productions, and it is an early example of that disregard for the method, proportions, and occasion of a writing which, with all common readers, deeply affects its power of interesting or instructing. Two years after, he published a most excellent tract on *The Hard Labour Bill*, which, concurring with the spirit excited by Howard's inquiries, laid the foundation of just reasoning on Reformatory Punishment. The *Letters on Usury*[1] are perhaps the best specimen of the exhaustive discussion of a moral or political question, leaving no objection, however feeble, unanswered, and no difficulty, however small, unexplained; remarkable also for the clearness and spirit of the style, for the full exposition which suits them to all intelligent readers, for the tender and skilful hand with which prejudice is touched, and for the urbanity of his admirable apology for projectors, addressed to Dr Smith, whose temper and manner he seems for a time to have imbibed. The *Introduction to the Principles of Morals and Politics*, printed before the *Letters*, but published after them, was the first sketch of his system, and is still the only account of it by himself.

The great merit of this work, and of his other writings in relation to *Jurisprudence* properly so called, is not within our present scope. To the Roman jurists belongs the praise of having allotted a separate portion of their Digest to the signification of the words of most frequent use in law and legal discussion.[1] Bentham not only first perceived and taught the great value of an introductory section, composed of definitions of general terms, as subservient to brevity and precision in every part of a code, but he also discovered the unspeakable importance of natural arrangement in jurisprudence, by rendering the mere place of a proposed law in such an arrangement a short and easy test of the fitness of the proposal.[2] But here he does not distinguish between the value of arrangement as scaffolding, and the inferior convenience of its being the very frame-work of the structure. Mr Bentham, indeed, is much more remarkable for laying down desirable rules for the determination of rights, and the punishment of wrongs, in general, than for weighing the various circumstances which require them to be modified in different countries and times in order to render them either more useful, more easily introduced, more generally respected, or more certainly executed. The art of legislation consists in thus applying the principles of jurisprudence to the situation, wants, interests, feelings, opinions, and habits, of each distinct community at any given time. It bears the same relation to jurisprudence which the mechanical arts bear to pure Mathematics. Many of these considerations serve to show, that the sudden establishment of new codes can seldom be practicable or effectual for their purpose; and that reformations, though founded on the principles of jurisprudence, ought to be not only adapted to the peculiar interests of a people, but engrafted on their previous usages, and brought into harmony with those national dispositions on which the execution of laws depends.[3] The Romans, under Justinian, adopted at least the true principle, if they did not apply it with sufficient freedom and boldness. They considered the multitude of occasional laws, and the still greater mass of usages, opinions, and determinations, as the materials of legislation, not precluding, but demanding a systematic arrangement of the whole by the supreme authority. Had the arrangement been more scientific, had there been a bolder examination and a more free reform of many particular branches, a model would have been offered for liberal imitation by modern lawgivers. It cannot be denied, without injustice and ingratitude, that Mr Bentham has done more than any other writer to rouse the spirit of juridical reformation, which is now gradually examining every part of law, and, when further progress is facilitated by digesting the present laws, will doubtless proceed to the improvement of all. Greater praise it is given to few to earn. It ought to satisfy Mr Bentham, for the disappointment of hopes which were not reasonable, that Russia should receive a code from him, or that North America could be brought to renounce the variety of her laws and institutions, on the single authority of a foreign philosopher, whose opinions had not worked their way either into legislation or into general reception in his own country. It ought also to dispose his followers to do fuller justice to the Romillys and Broughams, without whose prudence and energy, as well as reason and eloquence, the best plans of reformation must have continued a dead letter,—for whose sake it might have been fit to reconsider the obloquy heaped on their profession, and to show more general indulgence to all those whose chief offence seems to consist in their doubts whether sudden changes, almost always imposed by violence on a community, be the surest road to lasting improvement.

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[1] They were addressed to Mr George Wilson, who retired from the English bar to his native country, and died at Edinburgh in 1816; an early friend of Mr Bentham, and afterwards an intimate friend of Lord Ellenborough, Sir Vicary Gibbs, and of all the most eminent of his professional contemporaries. The rectitude of judgment, purity of heart, elevation of honour, the sternness only in integrity, the scorn of baseness, and indulgence towards weakness, which were joined in him with a gravity exclusive neither of feeling nor of pleasantry, contributed still more than his abilities and attainments of various sorts, to a moral authority with his friends, and in his profession, which few men more amply possessed, or more usefully exercised. The same character, somewhat softened, and the same influence, distinguished his closest friend, the late Mr Lens. Both were inflexible and incorruptible friends of civil and religious liberty, and both knew how to reconcile the warmest zeal for that sacred cause, with a charity towards their opponents, which partisans, often more violent than steady, treated as lukewarm. The present writer hopes that the good-natured reader will excuse him for having thus, perhaps unseasonably, bestowed heartfelt commendation on those who were above the pursuit of praise, and the remembrance of whose good opinion and good-will help to support him under a deep sense of faults and vices.

It is unfortunate that Ethical Theory, with which we are now chiefly concerned, is not the province in which Mr Bentham has reached the most desirable distinction. It may be remarked, both in ancient and in modern times, that whatever modifications prudent followers may introduce into the system of an innovator, the principles of the Master continue to mould the habitual dispositions, and to influence the practical tendency of the School. Mr Bentham preaches the principle of utility with the zeal of a discoverer. Occupied more in reflection than in reading, he knew not, or forgot, how often it had been the basis, and how generally an essential part, of moral systems.[1] That in which he really differs from others, is in the necessity which he teaches, and the example which he sets, of constantly bringing that principle before us. This peculiarity appears to us to be his radical error. In an attempt, of which the constitution of human nature forbids the success, he seems to us to have been led into fundamental errors in moral theory, and to have given to his practical doctrine a dangerous taint.

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[1] Digest. lib. l. tit. 16. *De Verborum Significatione.*

[2] See a beautiful article on Codification, in the *Edinburgh Review*, vol. XXIX. p. 217. It need no longer be concealed that it was contributed by Sir Samuel Romilly. The steadiness with which he held the balance in weighing the merits of his friend against his unfortunate defects, is an example of his union of the most commanding moral principle with a sensibility so warm, that, if it had been released from that stern authority, it would not so long have endured the coarseness and roughness of human concerns. From the tenderness of his feelings, and from an anger never roused but by cruelty and baseness, as much as from his genius and his pure taste, sprung that original and characteristic eloquence, which was the hope of the afflicted as well as the terror of the oppressor. If his oratory had not flowed so largely from this moral source, which years do not dry up, he would not perhaps have been the only example of an orator who, after the age of sixty, daily increased in polish, in vigour, and in splendour.

[3] An excellent medium between those who absolutely require new codes, and those who obstinately adhere to ancient usages, has been pointed out by M. Meyer, in his most justly celebrated work, *Institutions Judiciaires des Principaux Pays de l'Europe*, tome I. Introduction, p. 8, 9. La Haye et Amst. 1819–23, 6 vols. 8vo.

The confusion of *moral approbation* with the *moral qualities* which are its objects, common to Mr Bentham with many other philosophers, is much more uniform and prominent in him than in most others. This general error, already mentioned at the opening of this Dissertation, has led him more than others to assume, that because the principle of utility forms a necessary part of every moral theory, it ought therefore to be the chief motive of human conduct. Now it is evident that this assumption, rather tacitly than avowedly made, is wholly gratuitous. No practical conclusion can be deduced from the principle, but that we ought to cultivate those habitual dispositions which are the most effectual motives to useful actions. But before a regard to our own interest, or a desire to promote the welfare of men in general, be allowed to be the exclusive, or even the chief regulators of human conduct, it must be shown that they are the most effectual motives to such useful actions. It is demonstrated by experience that they are not. It is even owned by the most ingenious writers of Mr Bentham's school, that desires which are pointed to general and distant objects, although they have their proper place and their due value, are commonly very faint and ineffectual inducements to action. A theory founded on utility, therefore, requires that we should cultivate, as excitements to practice, those other habitual dispositions which we know by experience to be generally the source of actions beneficial to ourselves and our fellows; habits of feeling productive of habits of virtuous conduct, and in their turn strengthened by the re-action of these last. What is the result of experience on the choice of the objects of moral culture? Beyond all dispute, that we should labour to attain that state of mind in which all the social affections are felt with the utmost warmth, giving birth to more comprehensive benevolence, but not supplanted by it; when the moral sentiments most strongly approve what is right and good, without being perplexed by a calculation of consequences, though not incapable of being gradually rectified by reason, whenever they are decisively proved by experience not to correspond in some of their parts to the universal and perpetual effects of conduct. It is a false representation of human nature to affirm that "courage" is only "prudence."[2] They coincide in their effects, and it is always prudent to be courageous. But a man who fights *because* he thinks it more hazardous to yield, is not brave. He does not become brave till he feels cowardice to be base and painful, and till he is no longer in need of any aid from *prudence*. Even if it were the *interest* of every man to be bold, it is clear that so cold a consideration cannot prevail over the fear of danger. Where it seems to do so, it must be by the unseen power either of the fear of shame, or of some other powerful passion, to which it lends its name. It was long ago with striking justice observed by Aristotle, that he who abstains from present gratification, under a distinct apprehension of its painful consequences, is only *prudent*, and that he must acquire a disrelish for excess on its own account, before he deserves the name of a temperate man. It is only when the means are firmly and unalterably converted into ends, that the process of forming the mind is completed. Courage may then seek, instead of avoiding danger. Temperance may prefer abstemiousness to indulgence. Prudence itself may choose an orderly government of conduct, according to certain rules, without regard to the degree in which it promotes welfare. Benevolence must desire the happiness of others, to the exclusion of the consideration how far it is connected with that of the benevolent agent; and those alone can be accounted just who obey the dictates of justice from having thoroughly learned an habitual veneration for its strict rules and for its larger precepts. In that complete state the mind possesses no power of dissolving the combinations of thought and feeling which impel it to action. Nothing in this argument turns on the difference between implanted and acquired principles. As no man can cease, by any act of his, to *see* distance, though the power of seeing it be universally acknowledged to be an acquisition, so no man has the power to extinguish the affections and the moral sentiments, however much they may be thought to be acquired, any more than that of eradicating the bodily appetites. The best writers of Mr Bentham's school overlook the indissolubility of these associations, and appear not to bear in mind that their strength and rapid action constitute the perfect state of a moral agent.

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[1] See Notes and Illustrations, note V.

[2] Mr Mill's *Analysis of the Human Mind*, vol. II. p. 237. It would be unjust not to say that this book, partly perhaps from a larger adoption of the principles of Hartley, holds out fairer opportunities of negotiation with natural feelings and the doctrines of former philosophers, than any other production of the same school. But this very assertion about courage clearly shows at least a forgetfulness that courage, even if it were the offspring of prudence, would not for that reason be a species of it.

The pursuit of our own general welfare, or of that of mankind at large, though from their vagueness and coldness they are unfit habitual motives and unsafe ordinary guides of conduct, yet perform functions of essential importance in the moral system. The former, which we call self-love, preserves the balance of all the active principles which regard ourselves ultimately, and contributes to subject them to the authority of the moral principles.[1] The latter, which is general benevolence, regulates in like manner the equipoise of the narrower affections; quickens the languid, and checks the encroaching; borrows strength from pity, and even from indignation; receives some compensation, as it enlarges, in the addition of beauty and grandeur, for the weakness which arises from dispersion; enables us to look on all men as brethren, and overflows on every sentient being. The general interest of mankind, in truth, almost solely affects us through the affections of benevolence and sympathy; for the coincidence of general with individual interest, even where it is certain, is too dimly seen to produce any emotion which can impel to, or restrain from action. As a general truth, its value consists in its completing the triumph of morality, by demonstrating the absolute impossibility of forming any theory of human nature which does not preserve the superiority of virtue over vice; a great, though not a directly practical advantage.

The followers of Mr Bentham have carried to an unusual extent the prevalent fault of the more modern advocates of utility, who have dwelt so exclusively on the outward advantages of virtue as to have lost sight of the delight which is a part of virtuous feeling, and of the beneficial influence of good actions upon the frame of the mind. "Benevolence towards others," says Mr Mill, "produces a return of benevolence from them."[2] The fact is true, and ought to be stated. But how unimportant is it in comparison with that which is passed over in silence, the pleasure of the affection itself, which, if it could become lasting and intense, would convert the heart into a heaven! No one who has ever felt kindness, if he could accurately recall his feelings, could hesitate about their infinite superiority. The cause of the general neglect of this consideration is, that it is only when a gratification is something distinct from a state of mind, that we can easily learn to consider it as a pleasure. Hence the great error respecting the affections, where the *inherent* delight is not duly estimated, on account of that very peculiarity of being a part of a state of mind, which renders it unspeakably more valuable as independent of every thing without. The social affections are the only principles of human nature which have no direct pains. To have any of these desires is to be in a state of happiness. The malevolent passions have properly no pleasures; for that attainment of their purpose which is improperly so called, consists only in healing or assuaging the torture which envy, jealousy, and malice, inflict on the malignant mind. It might with as much propriety be said that the toothache and the stone have pleasures, because their removal is followed by an agreeable feeling. These bodily disorders, indeed, are often cured by the process which removes the suffering, but the mental distempers of envy and revenge are nourished by every act of odious indulgence which for a moment suspends their pain.

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[1] See Notes and Illustrations, note W.

[2] *Analysis of the Human Mind*, vol. II.

The same observation is applicable to every virtuous disposition, though not so obviously as to the benevolent affections. That a brave man is, on the whole, far less exposed to danger than a coward, is not the chief advantage of a courageous temper. Great dangers are rare; but the constant absence of such painful and mortifying sensations as those of fear, and the steady consciousness of superiority to what subdues ordinary men, are a perpetual source of inward enjoyment. No man who has ever been visited by a gleam of magnanimity can place any outward advantage of fortitude in comparison with the feeling of being always able fearlessly to defend a righteous cause.[1] Even *Humility*, in spite of first appearances, is a remarkable example. It has of late been unwarrantably used to signify that painful consciousness of inferiority which is the first stage of envy.[2] It is a term consecrated in Christian ethics to denote that disposition which, by inclining towards a modest estimate of our qualities, corrects the prevalent tendency of human nature to overvalue our merits and to overrate our claims. What can be a less doubtful or a much more considerable blessing than this constant sedative, which soothes and composes the irritable passions of vanity and pride? What is more conducive to lasting peace of mind than the consciousness of proficiency in that most delicate species of equity which, in the secret tribunal of conscience, labours to be impartial in the comparison of ourselves with others? What can so perfectly assure us of the purity of our moral sense, as the habit of contemplating, not that excellence which we have reached, but that which is still to be pursued;[3] of not considering how far we may outrun others, but how far we are from the goal?

Virtue has often outward advantages, and always inward delights; but the second, though constant, strong, inaccessible, and inviolable, are not easily considered by the common observer as apart from the virtue with which they are blended. They are so subtile and evanescent as to escape the distinct contemplation of all but the very few who meditate on the acts of mind. The outward advantages, on the other hand, cold, uncertain, dependent, and precarious as they are, yet stand out to the sense and to the memory, may be handled and counted, and are perfectly on a level with the general apprehension. Hence they have become the almost exclusive theme of all moralists who profess to follow reason. There is room for suspecting that a very general illusion prevails on this subject. Probably the smallest part of the pleasure of virtue, because it is the most palpable, has become the sign and mental representative of the whole. The outward and visible sign suggests insensibly the inward and mental delight. Those who display the external benefits of magnanimity and kindness, would speak with far less fervour, and perhaps less confidence, if their feelings were not unconsciously affected by the mental state which they overlook in their statements, though they feel some part of it when they write or speak on it. When they speak of what is *without*, they feel what was *within*, and their words excite the same feeling in others.

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[1] According to Cicero's definition of fortitude, "*Virtus pugnans pro æquitate.*" The remains of the original sense of *Virtus*, Manhood, give a beauty and force to these expressions, which cannot be preserved in our language. The Greek Αρετη, and the German *Tugend*, originally denoted *Strength*, afterwards *Courage*, and at last *Virtue*. But the happy derivation of *Virtus* from *Vir* gives an energy to the phrase of Cicero, which illustrates the use of etymology in the hands of a skilful writer.

[2] Mr MILL's *Analysis of the Human Mind*, vol. II. p. 222.

[3] For a description of vanity, by a great orator, see the Rev. R. HALL's *Sermon on Modern Infidelity*.

Is it not probable that much of our love of praise may be thus ascribed to humane and sociable pleasure in the sympathy of others with us? Praise is the symbol which represents sympathy, and which the mind insensibly substitutes for it in recollection and in language. Does not the desire of posthumous fame, in like manner, manifest an ambition for the fellow-feeling of our race, when it is perfectly unproductive of any advantage to ourselves? In this point of view, it may be considered as the passion of which the very existence proves the mighty power of disinterested desire. Every other pleasure from sympathy is confined to the men who are now alive. The love of fame alone seeks the sympathy of unborn generations, and stretches the chain which binds the race of man together, to an extent to which hope sets no bounds. There is a noble, even if unconscious, union of morality with genius in the mind of him who sympathizes with the masters who lived twenty centuries before him, in order that he may learn to command the sympathies of the countless generations who are to come.

In the most familiar, as well as in the highest instances, it would seem, that the inmost thoughts and sentiments of men are more pure than their language. Those who speak of "a regard to character," if they be serious, generally infuse into that word, unawares, a large portion of that sense in which it denotes the frame of the mind. Those who speak of "honour" very often mean a more refined and delicate sort of conscience, which ought to render the more educated classes of society alive to such smaller wrongs as the laborious and the ignorant can scarcely feel. What heart does not warm at the noble exclamation of the ancient poet: "Who is pleased by false honour, or frightened by lying infamy, but he who is false and depraved!" Every uncorrupted mind feels unmerited praise as a bitter reproach, and regards a consciousness of demerit as a drop of poison in the cup of honour. How different is the applause which truly delights us all, a proof that the consciences of others are in harmony with our own! "What," says Cicero, "is glory but the concurring praise of the good, the unbought approbation of those who judge aright of excellent virtue!" A far greater than Cicero rises from the purest praise of man, to more sublime contemplations.

> Fame is no plant that grows on mortal soil,
> But lives and spreads aloft, by those pure eyes
> And perfect witness of all-judging Jove.

Those who have most inculcated the doctrine of utility have given another notable example of the very vulgar prejudice which treats the unseen as insignificant. Tucker is the only one of them who occasionally considers that most important effect of human conduct which consists in its action on the frame of the mind, by fitting its faculties and sensibilities for their appointed purpose. A razor or a penknife would well enough cut cloth or meat; but if they were often so used, they would be entirely spoiled. The same sort of observation is much more strongly applicable to habitual dispositions, which, if they be spoiled, we have no certain means of replacing or mending. Whatever act, therefore, discomposes the moral machinery of mind, is more injurious to the welfare of the agent than most disasters from without can be; for the latter are commonly limited and temporary; the evil of the former spreads through the whole of life. Health of mind, as well as of body, is not only productive in itself of a greater sum of enjoyment than arises from other sources, but is the only condition of our frame in which we are capable of receiving pleasure from without. Hence it appears how incredibly absurd it is to prefer, on grounds of calculation, a present interest to the preservation of those mental habits on which our wellbeing depends. When they are most moral, they may often prevent us from obtaining advantages. It would be as absurd to desire to lower them for that reason, as it would be to weaken the body, lest its strength should render it more liable to contagious disorders of rare occurrence.

It is, on the other hand, impossible to combine the benefit of the general habit with the advantages of occasional deviation; for every such deviation either produces remorse, or weakens the habit, and prepares the way for its gradual destruction. He who obtains a fortune by the undetected forgery of a will, may indeed be honest in his other acts; but if he had such a scorn of fraud before as he must himself allow to be generally useful, he must suffer a severe punishment from contrition; and he will be haunted with the fears of one who has lost his own security for his good conduct. In all cases, if they be well examined, his loss by the distemper of his mental frame will outweigh the profits of his vice.

By repeating the like observation on similar occasions, it will be manifest that the infirmity of recollection, aggravated by the defects of language, gives an appearance of more selfishness to man than truly belongs to his nature; and that the effect of active agents upon the habitual state of mind, one of the considerations to which the epithet " sentimental" has of late been applied in derision, is really among the most serious and reasonable objects of moral philosophy. When the internal pleasures and pains which *accompany* good and bad feelings, or rather form a part of them, and the internal advantages and disadvantages which *follow* good and bad actions, are sufficiently considered, the comparative importance of *outward consequences* will be more and more narrowed; so that the Stoical philosopher may be thought almost excusable for rejecting it altogether, were it not an indispensably necessary consideration for those in whom right habits of feeling are not sufficiently strong. They alone are happy, or even truly virtuous, who have little need of it.

The later moralists who adopt the principle of utility, have so *misplaced* it, that in their hands it has as great a tendency as any theoretical error can have, to lessen the intrinsic pleasure of virtue, and to unfit our habitual feelings for being the most effectual inducements to good conduct. This is the natural tendency of a discipline which brings utility too closely and frequently into contact with action. By this habit, in its best state, an essentially weaker motive is gradually substituted for others which must always be of more force. The frequent appeal to utility as the standard of action tends to introduce an uncertainty with respect to the conduct of other men, which would render all intercourse insupportable. It affords also so fair a disguise for selfish and malignant passions, as often to hide their nature from him who is their prey. Some taint of these mean and evil principles will at least creep in, and by their venom give an animation not its own to the cold desire of utility. The moralists who take an active part in those affairs which often call out unamiable passions, ought to guard with peculiar watchfulness against such self-delusions. The sin that must most easily beset them, is that of sliding from general to particular consequences, —that of trying single actions, instead of dispositions, habits, and rules, by the standard of utility,—that of authorizing too great a latitude for discretion and policy in moral conduct,—that of readily allowing exceptions to the most important rules,—that of too lenient a censure of the use of doubtful means when the end seems to them good,—and that of believing unphilosophically, as well as dangerously, that there can be any measure or scheme so useful to the world as the existence of men who would not do a base thing for any public advantage. It was said of Andrew Fletcher, " he would lose his life to *serve* his country, but would not do a base thing to *save* it." Let those preachers of utility who suppose that such a man sacrifices *ends* to *means*, consider whether the scorn of baseness be not akin to the contempt of danger, and whether a nation composed of such men would not be invincible. But theoretical principles are counteracted by a thousand causes, which confine their mischief as well as circumscribe their benefits. Men are never so good or so bad as their opinions. All that can be with reason apprehended is, that they may always produce some part of their natural evil, and that the mischief will be greatest among the many who seek excuses for these passions. Aristippus found in the Socratic representation of the union of virtue and happiness a pretext for sensuality; and many Epicureans became voluptuaries in spite of the example of their master; easily dropping by degrees the limitations by which he guarded his doctrines. In proportion as a man accustoms himself to be influenced by the utility of particular acts, without regard to rules, he approaches to the casuistry of the Jesuits, and to the practical maxims of Cæsar Borgia.

Injury on this as on other occasions has been suffered by *Ethics*, from its close affinity to *Jurisprudence.* The true and eminent merit of Mr Bentham is that of a reformer of jurisprudence. He is only a moralist with a view to being a jurist; and he sometimes becomes for a few hurried moments a metaphysician with a view to laying the foundation of both the moral sciences. Both he and his followers have treated Ethics too *juridically.* They do not seem to be aware, or at least they do not bear constantly in mind, that there is an essential difference in the subjects of these two sciences.

The object of law is the prevention of actions injurious to the community. It considers the dispositions from which they flow only *indirectly*, to ascertain the likelihood of their recurrence, and thus to determine the necessity and the means of preventing them. The *direct* object of Ethics is only mental disposition. It considers actions *indirectly* as the signs by which such dispositions are manifested. If it were possible for the mere moralist to see that a moral and amiable temper was the mental source of a bad action, he could not cease to approve and love the temper, as we sometimes presume to suppose may be true of the judgments of the Searcher of Hearts. Religion necessarily coincides with morality in this respect; and it is the peculiar distinction of Christianity that it places the seat of virtue in the heart. Law and Ethics are necessarily so much blended, that in many intricate combinations the distinction becomes obscure. But in all strong cases the difference is evident. Thus, law punishes the most sincerely repentant; but wherever the soul of the penitent can be thought to be thoroughly purified, religion and morality receive him with open arms.

It is needless, after these remarks, to observe, that those whose habitual contemplation is directed to the rules of action, are likely to underrate the importance of feeling and disposition; an error of very unfortunate consequences, since the far greater part of human actions flow from these neglected sources; while the law interposes only in cases which may be called exceptions, which are now rare, and ought to be less frequent.

The coincidence of Mr Bentham's school with the ancient Epicureans in the disregard of the pleasures of taste and of the arts dependent on imagination, is a proof both of the inevitable adherence of much of the popular sense of the words " interest" and " pleasure," to the same words in their philosophical acceptation, and of the pernicious influence of narrowing " utility" to mere visible and tangible objects, to the exclusion of those which form the larger part of human enjoyment.

The mechanical philosophers who, under Descartes and Gassendi, began to reform Physics in the seventeenth century, attempted to explain all the appearances of nature by an immediate reference to the figure of particles of matter impelling each other in various directions, and with unequal force, but in all other points alike. The communication of motion by impulse they conceived to be perfectly simple and intelligible. It never occurred to them, that the movement of one ball when another is driven against it, is a fact of which no explanation can be given which will amount to more than a statement of its constant occurrence. That no body can act where it is not, appeared to them as self-evident as that the whole is equal to all the parts. By this axiom they understood that no body moves another without touching it. They did not perceive, that it was only self-evident where it means that no body can act *where it has not the power of acting:* and that if it be understood more largely, it is a mere assumption of the proposition on which their whole system rested. Sir Isaac Newton reformed Physics, not by simplifying that science, but by rendering it much more complicated. He introduced into it the force of attraction, of which he ascertained many laws, but which even he did not dare to represent as being as intelligible and as conceivably ultimate as impulsion itself. It was necessary for Laplace to introduce intermediate laws, and to calculate disturbing forces, before the phenomena of the heavenly bodies could be reconciled even to Newton's more complex theory. In the present state of physical and chemical knowledge, a man who should attempt to refer all the immense variety of facts to the simple impulse of the Cartesians, would have no chance of serious confutation. The number of laws augments with the progress of knowledge. The speculations of the followers of Mr Bentham are not unlike the unsuccessful attempt of the Cartesians. Mr Mill, for example, derives the whole theory of Government[1] from the single fact, that every man pursues his interest when he knows it; which he assumes to be a sort of self-evident practical principle, if such a phrase be not contradictory. That a man's pursuing the interest of another, or indeed any other object in nature, is just as *conceivable* as that he should pursue his own interest, is a proposition which seems never to have occurred to this acute and ingenious writer. Nothing, however, can be more certain than its truth, if the term "interest" be employed in its proper sense of general wellbeing, which is the only acceptation in which it can serve the purpose of his arguments. If, indeed, the term be employed to denote the gratification of a predominant desire, his proposition is self-evident, but wholly unserviceable in his argument; for it is clear that individuals and multitudes often desire what they know to be most inconsistent with their general welfare. A nation, as much as an individual, and sometimes more, may not only mistake its interest, but, perceiving it clearly, may prefer the gratification of a strong passion to it.[2] The whole fabric of his political reasoning seems to be overthrown by this single observation; and instead of attempting to explain the immense variety of political facts by the simple principle of a contest of interests, we are reduced to the necessity of once more referring them to that variety of passions, habits, opinions, and prejudices, which we discover only by experience. Mr Mill's *Essay on Education*[3] affords another example of the inconvenience of leaping at once from the most general laws, to a multiplicity of minute appearances. Having assumed, or at least inferred from insufficient premises, that the intellectual and moral character is entirely formed by circumstances, he proceeds, in the latter part of the essay, as if it were a necessary consequence of that doctrine that we might easily acquire the power of combining and directing circumstances in such a manner as to produce the best possible character. Without disputing for the present the theoretical proposition, let us consider what would be the reasonableness of similar expectations in a more easily intelligible case. The general theory of the winds is pretty well understood; we know that they proceed from the rushing of air from those portions of the atmosphere which are more condensed, into those which are more rarefied; but how great a chasm is there between that simple law and the great variety of facts which experience teaches us respecting winds! The constant winds between the tropics are large and regular enough to be in some measure capable of explanation; but who can tell why, in variable climates, the wind blows to-day from the east, to-morrow from the west? Who can foretell what its shiftings and variations are to be? Who can account for a tempest on one day, and a calm on another? Even if we could foretell the irregular and infinite variations, how far might we not still be from the power of combining and guiding their causes? No man but the lunatic in the story of Rasselas ever dreamt that he could command the weather. The difficulty plainly consists in the multiplicity and minuteness of the circumstances which act on the atmosphere. Are those which influence the formation of the human character likely to be less minute and multiplied?

The style of Mr Bentham underwent a more remarkable revolution than perhaps befell that of any other celebrated writer. In his early works, it was clear, free, spirited, often and seasonably eloquent. Many passages of his later writings retain the inimitable stamp of genius; but he seems to have been oppressed by the vastness of his projected works,—to have thought that he had no longer more than leisure to preserve the heads of them,—to have been impelled by a fruitful mind to new plans before he had completed the old. In this state of things, he gradually ceased to use words for conveying his thoughts to others, but merely employed them as a short-hand to preserve his meaning for his own purpose. It was no wonder that his language should thus become obscure and repulsive. Though many of his technical terms are in themselves exact and pithy, yet the overflow of his vast nomenclature was enough to darken his whole diction.

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[1] *Essay on Government*, originally printed in the Supplement to the fourth, fifth, and sixth editions of the Encyclopædia Britannica.

[2] The same mode of reasoning has been adopted by the writer of a late criticism on Mr MILL's *Essay*. See *Edinburgh Review*, No. 97, March 1829.

[3] In the Supplement to the Encyclopædia Britannica.

It was at this critical period that the arrangement and translation of his manuscripts were undertaken by M. Dumont, a generous disciple, who devoted a genius formed for original and lasting works, to diffuse the principles and promote the fame of his master. He whose pen Mirabeau did not disdain to borrow,—who, in the same school with Romilly, had studiously pursued the grace as well as the force of composition,—was perfectly qualified to strip of its uncouthness a philosophy which he understood and admired. As he wrote in a general language, he propagated its doctrines throughout Europe, where they were beneficial to jurisprudence, but perhaps injurious to the cause of reformation in government. That they became more popular abroad than at home, is partly to be ascribed to the taste and skill of M. Dumont; partly to that tendency towards free speculation and bold reform which was more prevalent among nations newly freed, or impatiently aspiring to freedom, than in a people long satisfied with the possession of a system of government like that which others were struggling to obtain, and not yet aware of the imperfections and abuses in their laws, to the amendment of which a cautious consideration of Mr Bentham's works will undoubtedly most materially contribute.

DUGALD STEWART.[1]

Manifold are the discouragements rising up at every step in that part of this Dissertation which extends to very recent times. No sooner does the writer escape from the angry disputes of the living, than he may feel his mind clouded by the name of a departed friend. But there are happily men whose fame is brightened by free discussion, and to whose memory an appearance of belief that they needed tender treatment would be a grosser injury than it could suffer from a respectable antagonist.

Dugald Stewart was the son of Dr Matthew Stewart, Professor of Mathematics in the University of Edinburgh; a station immediately before filled by Maclaurin, on the recommendation of Newton. Hence the poet spoke of "the philosophic sire and son."[2] He was educated at Edinburgh, and he heard the lectures of Reid at Glasgow. He was early associated with his father in the duties of the Mathematical Professorship; and during the absence of Dr Adam Ferguson as Secretary to the Commissioners sent to conclude a peace with North America, he occupied the chair of Moral Philosophy. He was appointed to the Professorship on the resignation of Ferguson, not the least distinguished among the modern moralists inclined to the Stoical school.

This office, filled in immediate succession by Ferguson, Stewart, and Brown, received a lustre from their names, which it owed in no degree to its modest exterior or its limited advantages; and was rendered by them the highest dignity, in the humble, but not obscure, establishments of Scottish literature. The lectures of Mr Stewart, for a quarter of a century, rendered it famous through every country where the light of reason was allowed to penetrate. Perhaps few men ever lived, who poured into the breasts of youth a more fervid and yet reasonable love of liberty, of truth, and of virtue. How many are still alive, in different countries, and in every rank to which education reaches, who, if they accurately examined their own minds and lives, would not ascribe much of whatever goodness and happiness they possess, to the early impressions of his gentle and persuasive eloquence! He lived to see his disciples distinguished among the lights and ornaments of the council and the senate.[1] He had the consolation to be sure that no words of his promoted the growth of an impure taste, of an exclusive prejudice, of a malevolent passion. Without derogation from his writings, it may be said that his disciples were among his best works. He, indeed, who may justly be said to have cultivated an extent of mind which would otherwise have lain barren, and to have contributed to raise virtuous dispositions where the natural growth might have been useless or noxious, is not less a benefactor of mankind, and may *indirectly* be a larger contributor to knowledge, than the author of great works, or even the discoverer of important truths. The system of conveying scientific instruction to a large audience by lectures, from which the English universities have in a great measure departed, renders his qualities as a lecturer a most important part of his merit in a Scottish university which still adheres to the general method of European education. Probably no modern ever exceeded him in that species of eloquence which springs from sensibility to literary beauty and moral excellence; which neither obscures science by prodigal ornament, nor disturbs the serenity of patient attention; but though it rather calms and soothes the feelings, yet exalts the genius, and insensibly inspires a reasonable enthusiasm for whatever is good and fair.

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[1] Born in 1753; died in 1828.

[2] Burns.

He embraced the philosophy of Dr Reid, a patient, modest, and deep thinker,[2] who, in his first work (*Enquiry into the Human Mind*), deserves a commendation more descriptive of a philosopher than that bestowed by Professor Cousin—of having made "a vigorous protest against scepticism on behalf of common sense." His observations on suggestion, on natural signs, on the connection between what he calls sensation and perception, though perhaps occasioned by Berkeley, whose idealism Reid had once adopted, are marked by the genuine spirit of original observation. As there are too many who seem more wise than they are, so it was the more uncommon fault of Reid to appear less a philosopher than he really was. Indeed his temporary adoption of Berkeleianism is a proof of an unprejudiced and acute mind. Perhaps no man ever rose finally above the seductions of that simple and ingenious system, who had not sometimes tried their full effect by surrendering his whole mind to them.

But it is never with entire impunity that philosophers borrow vague and inappropriate terms from vulgar use. Never did man afford a stronger instance of the danger than Reid, in his two most unfortunate terms, *Common Sense* and *Instinct*. Common Sense is that average portion of understanding, possessed by most men, which, as it is nearly always applied to conduct, has acquired an almost exclusively practical sense. Instinct is the habitual power of producing effects like contrivances of reason, yet so far beyond the intelligence and experience of the agent, as to be utterly inexplicable by reference to them. No man, if he had been in search of improper words, could have discovered any more unfit than these two, for denoting that *law*, or *state*, or *faculty* of mind, which compels us to acknowledge certain simple and very abstract truths, not being identical propositions, to lie at the foundation of all reasoning, and to be the necessary ground of all belief.

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[1] As an example of Mr Stewart's school may be mentioned Francis Horner, a favourite pupil, and, till his last moment, an affectionate friend. The short life of this excellent person is worthy of serious contemplation, by those more especially, who, in circumstances like his, enter on the slippery path of public affairs. Without the aids of birth or fortune, in an assembly where aristocratical propensities prevail,—by his understanding, industry, pure taste, and useful information,—still more by modest independence, by steadiness and sincerity, joined to moderation,—by the stamp of unbending integrity, and by the conscientious considerateness which breathed through his well-chosen language,—he raised himself, at the early age of thirty-six, to a moral *authority* which, without these qualities, no brilliancy of talents or power of reasoning could have acquired. No eminent speaker in Parliament owed so much of his success to his moral *character*. His high place was therefore honourable to his audience and to his country. Regret for his death was expressed with touching unanimity from every part of a divided assembly, unused to manifestations of sensibility, abhorrent from theatrical display, and whose tribute on such an occasion derived its peculiar value from their general coldness and sluggishness. The tears of those to whom he was unknown were shed over him; and at the head of those by whom he was "praised, wept, and honoured," was one, whose commendation would have been more enhanced in the eye of Mr Horner, by his discernment and veracity, than by the signal proof of the concurrence of all orders, as well as parties, which was afforded by the name of Howard.

[2] Those who may doubt the justice of this description will do well to weigh the words of the most competent of judges, who, though candid and even indulgent, was not prodigal of praise. "It is certainly very rare that a piece so *deeply philosophical* is wrote with so much spirit, and affords so much entertainment to the reader. Whenever I enter into your ideas, no man appears to express himself with greater perspicuity. Your style is so correct and so good English, that I found not any thing worth the remarking. I beg my compliments to my friendly adversaries Dr Campbell and Dr Gerard, and also to Dr Gregory, whom I suspect to be of the same disposition, though he has not openly declared himself such." (*Letter from Mr Hume to Dr Reid:* STEWART'S *Biographical Memoirs*, p. 417.)

The latter part of the above sentences (written after a perusal of the proof-sheets of Dr Reid's *Enquiry*, but before its publication) sufficiently shows, that Mr Hume felt no displeasure against Reid and Campbell, undoubtedly his most formidable antagonists, however he might resent the language of Dr Beattie, an amiable man, an elegant and tender poet, and a good writer on miscellaneous literature in prose, but who, in his *Essay on Truth*—an unfair appeal to the multitude on philosophical questions—indulged himself in the personalities and invectives of a popular pamphleteer.

Long after the death of Dr Reid, his philosophy was taught at Paris by M. Royer Collard,[1] who, on the restoration of free debate, became the most philosophical orator of his nation, and now fills, with impartiality and dignity, the chair of the Chamber of Deputies. His ingenious and eloquent scholar, Professor Cousin, dissatisfied with what he calls "the sage and timid" doctrines of Edinburgh, which he considered as only a vigorous protest, on behalf of common sense, against the scepticism of Hume, sought in Germany for a philosophy of "such a masculine and brilliant character as might command the attention of Europe, and be able to struggle with success on a great theatre, against the genius of the adverse school."[2] It may be questioned whether he found in Kant more than the same *vigorous protest*, under a more systematic form, with an immense nomenclature, and constituting a philosophical edifice of equal symmetry and vastness. The preference of the more boastful system, over a philosophy thus chiefly blamed for its modest pretensions, does not seem to be entirely justified by its permanent authority in the country which gave it birth; where, however powerful its influence still continues to be, its doctrines do not appear to have now many supporters: and, indeed, the accomplished Professor himself rapidly shot through Kantianism, and now appears to rest or to stop at the doctrines of Schelling and Hegel, at a point so high, that it is hard to descry from it any distinction between objects,—even that indispensable distinction between *Reality* and *Illusion*. As the works of Reid, and those of Kant, otherwise so different, appear to be simultaneous efforts of the conservative power of philosophy to expel the mortal poison of scepticism, so the exertions of M. Royer Collard and M. Cousin, however at variance in metaphysical principles, seem to have been chiefly roused by the desire of delivering Ethics from that fatal taint of personal, and, indeed, gross interest, which that science had received in France from the followers of Condillac, especially Helvetius, St Lambert, and Cabanis. The success of these attempts to render Speculative Philosophy once more popular in the country of Descartes, has already been considerable. The French youth, whose desire of knowledge and love of liberty afford an auspicious promise of the succeeding age, have eagerly received doctrines, of which the moral part is so much more agreeable to their liberal spirit, than the selfish theory, generated in the stagnation of a corrupt, cruel, and dissolute tyranny.

These agreeable prospects bring us easily back to our subject; for though the restoration of Speculative Philosophy in the country of Descartes is due to the precise statement and vigorous logic of M. Royer Collard, the modifications introduced by him into the doctrine of Reid coincide with those of Mr Stewart, and would have appeared to agree more exactly, if the forms of the French philosopher had not been more dialectical, and the composition of Mr Stewart had retained less of that oratorical character, which belonged to a justly celebrated speaker. Amidst excellencies of the highest order, his writings, it must be confessed, leave some room for criticism. He took precautions against offence to the feelings of his contemporaries, more anxious and frequent than the impatient searcher for truth may deem necessary. For the sake of promoting the favourable reception of philosophy itself, he studies perhaps too visibly to avoid whatever might raise up prejudices against it. His gratitude and native modesty dictated a superabundant care in softening and excusing his dissent from those who had been his own instructors, or who were the objects of general reverence. Exposed by his station, both to the assaults of political prejudice, and to the religious animosities of a country where a few sceptics attacked the slumbering zeal of a Calvinistic people, it would have been wonderful if he had not betrayed more wariness than would have been necessary or becoming in a very different position. The fulness of his literature seduced him too much into multiplied illustrations. Too many of the expedients happily used to allure the young may unnecessarily swell his volumes. Perhaps a successive publication in separate parts made him more voluminous than he would have been if the whole had been at once before his eyes. A peculiar susceptibility and delicacy of taste produced forms of expression, in themselves extremely beautiful, but of which the habitual use is not easily reconcilable with the condensation desirable in works necessarily so extensive. If, however, it must be owned that the caution incident to his temper, his feelings, his philosophy, and his station, has somewhat lengthened his composition, it is not less true, that some of the same circumstances have contributed towards those peculiar beauties which place him at the head of the most adorned writers on philosophy in our language.

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[1] Fragments of his lectures have been recently published in a French translation of Dr Reid, by M. Jonffroy: *Œuvres Completes de* Thomas Reid, vol. IV. Paris, 1828.

[2] *Cours de Philosophie*, par M. Cousin, leçon xii. Paris, 1828.

Few writers rise with more grace from a plain groundwork, to the passages which require greater animation or embellishment. He gives to narrative, according to the precept of Bacon, the colour of the time, by a selection of happy expressions from original writers. Among the secret arts by which he diffuses elegance over his diction, may be remarked the skill which, by deepening or brightening a shade in a secondary term, by opening partial or preparatory glimpses of a thought to be afterwards unfolded, unobservedly heightens the import of a word, and gives it a new meaning, without any offence against old use. It is in this manner that philosophical originality may be reconciled to purity and stability of speech,—that we may avoid new terms, which are the easy resource of the unskilful or the indolent, and often a characteristic mark of writers who love their language too little to feel its peculiar excellencies, or to study the art of calling forth its powers.

He reminds us not unfrequently of the character given by Cicero to one of his contemporaries, "who expressed refined and abstruse thought in soft and transparent diction." His writings are a proof that the mild sentiments have their eloquence as well as the vehement passions. It would be difficult to name works in which so much refined philosophy is joined with so fine a fancy,—so much elegant literature, with such a delicate perception of the distinguishing excellencies of great writers, and with an estimate in general so just of the services rendered to knowledge by a succession of philosophers. They are pervaded by a philosophical benevolence, which keeps up the ardour of his genius, without disturbing the serenity of his mind,—which is felt in his reverence for knowledge, in the generosity of his praise, and in the tenderness of his censure. It is still more sensible in the general tone with which he relates the successful progress of the human understanding, among many formidable enemies. Those readers are not to be envied who limit their admiration to particular parts, or to excellencies merely literary, without being warmed by the glow of that honest triumph in the advancement of knowledge, and of that assured faith in the final prevalence of truth and justice, which breathe through every page of them, and give the unity and dignity of a moral purpose to the whole of these classical works.

He has often quoted poetical passages, of which some throw much light on our mental operations. If he sometimes prized the moral common-places of Thomson and the speculative fancy of Akenside more highly than the higher poetry of their betters, it was not to be wondered at that the metaphysician and the moralist should sometimes prevail over the lover of poetry. His natural sensibility was perhaps occasionally cramped by the cold criticism of an unpoetical age; and some of his remarks may be thought to indicate a more constant and exclusive regard to diction than is agreeable to the men of a generation who have been trained by tremendous events to a passion for daring inventions, and to an irregular enthusiasm, impatient of minute elegancies and refinement. Many of those beauties which his generous criticism delighted to magnify in the works of his contemporaries, have already faded under the scorching rays of a fiercer sun.

Mr Stewart employed more skill in contriving, and more care in concealing, his very important reforms of Reid's doctrines, than others exert to maintain their claims to originality. Had his well-chosen language of "laws of human thought or belief" been at first adopted in that school, instead of "instinct" and "common sense," it would have escaped much of the reproach (which Dr Reid himself did not merit) of shallowness and popularity. Expressions so exact, employed in the opening, could not have failed to influence the whole system, and to have given it, not only in the general estimation, but in the minds of its framers, a more scientific complexion. In those parts of Mr Stewart's speculations in which he most departed from his general principles, he seems sometimes, as it were, to be suddenly driven back by what he unconsciously shrinks from as ungrateful apostasy; and to be desirous of making amends to his master, by more harshness, than is otherwise natural to him, towards the writers whom he has insensibly approached. Hence perhaps the unwonted severity of his language towards Tucker and Hartley. It is thus at the very time when he largely adopts the Principle of Association in his excellent Essay on the Beautiful,[1] that he treats most rigidly the latter of these writers, to whom, though neither the discoverer nor the sole advocate of that principle, it surely owes the greatest illustration and support.

In matters of far other importance, causes perhaps somewhat similar may have led to the like mistake. When he absolutely contradicts Dr Reid, by truly stating that "it is more philosophical to resolve the power of habit into the association of ideas, than to resolve the association of ideas into habit,"[2] he, in the sequel of the same volume,[3] refuses to go farther than to own, that "the theory of Hartley concerning the *origin* of our affections, and of the moral sense, is a most *ingenious refinement on the selfish system*, and that by means of it the force of many of the common reasonings against that system is *eluded;*" though he somewhat inconsistently allows, that "active principles which, arising from circumstances in which all the situations of mankind must agree, are therefore common to the whole species, at whatever period of life they may appear, are to be regarded as a part of human nature, no less than the instinct of suction; in the same manner as the acquired perception of distance, by the eye, is to be ranked among the perceptive powers of man, no less than the original perceptions of the other senses."[4] In another place also he makes a remark on mere beauty, which might have led him to a more just conclusion respecting the theory of the origin of the affections and the moral sense: "It is scarcely necessary for me to observe, that, in those instances where association operates in heightening (or he might have said creates) the pleasures we receive from sight, the pleasing emotion continues still to appear, to our consciousness, simple and uncompounded."[5] To this remark he might have added, that until all the separate pleasures be melted into one,—as long as any of them are discerned and felt as distinct from each other,—the associations are incomplete, and the qualities which gratify are not called by the name of beauty. In like manner, as has been repeatedly observed, it is only when all the separate feelings, pleasurable and painful, excited by the contemplation of voluntary action, are lost in the general sentiments of approbation or disapprobation,—when these general feelings retain no trace of the various emotions which originally attended different actions,—when they are held in a state of perfect fusion by the habitual use of the words used in every language to denote them,—that conscience can be said to exist, or that we can be considered as endowed with a moral nature. The theory which thus ascribes the uniform formation of the moral faculty to universal and paramount laws, is not a refinement of the selfish system, nor is it any modification of that hypothesis. The partisans of selfishness maintain, that in acts of will the agent must have a view to the pleasure or happiness which he hopes to reap from it. The philosophers who regard the *social affections* and the *moral sentiments* as formed by a process of association, on the other hand, contend that these affections and sentiments must work themselves clear from every particle of *self-regard*, before they deserve the names of benevolence and of conscience. In the actual state of *human motives*, the two systems are not to be likened, but to be contrasted to each other. It is remarkable that Mr Stewart, who admits the " question respecting the *origin* of the affections to be rather curious than important,"[1] should have held a directly contrary opinion respecting the moral sense;[2] to which these words, in his sense of them, seem to be equally applicable. His meaning in the former affirmation is, that if the affections be *acquired*, yet they are justly called *natural;* and if their origin be personal, yet their nature may and does *become* disinterested. What circumstance distinguishes the former from the latter case? With respect to the origin of the affections, it must not be overlooked that his language is somewhat contradictory. For if the theory on that subject from which he dissents were merely " a refinement on the selfish system," its truth or falsehood could not be represented as subordinate, since the controversy would continue to relate to the existence of disinterested motives of human conduct.[3] It may also be observed, that he uniformly represents his opponents as deriving the affections from *self-love*, which, in its proper sense, is not the source to which they refer even avarice; and which is itself derived from other antecedent principles, some of which are inherent, and some acquired. If the object of this theory of the rise of the most important feelings of human nature were, as our philosopher supposes, " to *elude* objections against the *selfish system*," it would be at best worthless. Its positive merits are several. It affirms the actual disinterestedness of human motives, as strongly as Butler himself. The explanation of the mental law, of which benevolence and conscience are formed habitually, when it is contemplated deeply, impresses on the mind the truth that they not only *are* but *must* be disinterested. It confirms, as it were, the testimony of consciousness, by exhibiting to the understanding the means employed to insure the production of disinterestedness. It affords the only effectual answer to the prejudice against the disinterested theory, from the multiplication of ultimate facts and implanted principles, which, under all its other forms, it seems to require. No room is left for this prejudice by a representation of disinterestedness, which *ultimately* traces its formation to principles almost as simple as those of Hobbes himself. Lastly, every step in just generalization is an advance in philosophy. No one has yet shown, either that man is not actually disinterested, or that he may not have been destined to become so by such a process as has been described:—the cause to which the effects are ascribed is a real agent, which seems adequate to the appearance; and if future observation should be found to require that the theory shall be confined within narrower limits, such a limitation will not destroy its value.

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[1] STEWART'S *Philosophical Essays*, part ii. essay i. especially chap. vi. The condensation, if not omission, of the discussion of the theories of Buffier, Reynolds, Burke, and Price, in this essay, would have lessened that temporary appearance which is unsuitable to a scientific work.

[2] *Elements of the Philosophy of the Human Mind*, vol. I. p. 281, edit. 1792, 4to.

[3] *Ibid.* p. 383.

[4] *Ibid.* p. 385.

[5] *Philosophical Essays*, part ii. essay i. chap. vi.

The acquiescence of Mr Stewart in Dr Reid's general representation of our mental constitution, led him to indulge more freely the natural bent of his understanding, by applying it to theories of character and manners, of life and literature, of taste and the arts, more than to the consideration of those more simple principles which rule over human nature under every form. His chief work, as he frankly owns, is indeed rather a collection of such theories, pointing toward the common end of throwing light on the structure and functions of the mind, than a systematic treatise, such as might be expected from the title of "Elements." It is in essays of this kind that he has most surpassed other cultivators of mental philosophy. His remarks on the effects of casual associations may be quoted as a specimen of the most original and just thoughts, conveyed in the best manner.[1] In this beautiful passage, he proceeds from their power of confusing speculation, to that of disturbing experience and of misleading practice; and ends with their extraordinary effect in bestowing on trivial, and even ludicrous circumstances, some portion of the dignity and sanctity of those sublime principles with which they are associated. The style, at first only clear, afterwards admitting the ornaments of a calm and grave elegance, at last rising to as high a strain as philosophy will endure, and of which all the parts (various as their nature is) are held together by an invisible thread of gentle transition, affords a specimen of adaptation of manner to matter which it will be hard to match in any philosophical writer. Another very fine remark, which seems to be as original as it is just, may be quoted as a sample of those beauties with which his writings abound. "The apparent coldness and selfishness of mankind may be traced, in a great measure, to a want of attention and a want of imagination. In the case of those misfortunes which happen to ourselves or our near connections, neither of these powers is necessary to make us acquainted with our situation. But without an uncommon degree of both, it is impossible for any man to comprehend completely the situation of his neighbour, or to have an idea of the greater part of the distress which exists in the world. If we feel more for ourselves than for others, in the former case the facts are more fully before us than they can be in the latter."[2] Yet several parts of his writings afford the most satisfactory proof, that his abstinence from what is commonly called metaphysical speculation, arose from no inability to pursue it with signal success. As examples, his observations on *General Terms*, and on *Causation*, may be appealed to with perfect confidence. In the first two Dissertations of the volume bearing the title of *Philosophical Essays*, he with equal boldness and acuteness grapples with the most extensive and abstruse questions of mental philosophy, and points out both the sources and the uttermost boundaries of human knowledge with a Verulamean hand. In another part of his writings, he calls what are denominated first principles of experience, "*fundamental laws of human belief, or primary elements of human reason*;"[3] which last form of expression has so close a resemblance to the language of Kant, that it should have protected the latter from the imputation of writing jargon.

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[1] *Outlines of Moral Philosophy*, p. 93.

[2] *Outlines*, p. 117. " This is the most important question that can be stated with respect to the Theory of Morals."

[3] In the *Philosophy of the Active and Moral Powers of Man* (vol. I. p. 164) Mr Stewart has done more manifest injustice to the Hartleian theory, by calling it "a doctrine *fundamentally the same*" *with the selfish system*, and especially by representing Hartley, who ought to be rather classed with Butler and Hume, as agreeing with Gay, Tucker, and Paley.

Mr Stewart's excellent volume entitled *Outlines of Moral Philosophy*,[4] though composed only as a text-book for the use of his hearers, is one of the most decisive proofs that he was perfectly qualified to unite precision with ease, to be brief with the utmost clearness, and to write with becoming elegance in a style where the meaning is not overladen by ornaments. This volume contains his properly *Ethical Theory*,[5] which is much expanded, but not substantially altered, in his *Philosophy of the Active and Moral Powers*,[6]—a work almost posthumous, and composed under circumstances which give it a deeper interest than can be inspired by any desert in science. Though, with his usual modesty, he manifests an anxiety to fasten his ethical theory to the kindred speculations of other philosophers of the Intellectual School, especially to those of Cudworth, recently clothed in more modern phraseology by Price, yet he still shows that independence and originality which all his aversion from parade could not entirely conceal. *Right, duty, virtue, moral obligation*, and the like or the opposite forms of expression, represent, according to him, certain thoughts, which arise necessarily and instantaneously in the mind (or in the reason, if we take that word in the large sense in which it denotes all that is not emotive) at the contemplation of actions, and which are utterly incapable of all resolution, consequently of all explanation, and which can be known only by being experienced. These thoughts or ideas, or by whatever other name they may be called, are followed as inexplicably, but as inevitably, by pleasurable and painful emotions, which suggest the conception of *moral beauty;* a quality of human actions distinct from their *adherence to or deviation from rectitude*, though generally coinciding with it. The question which a reflecting reader will here put is, whether any purpose is served by the introduction of the intermediate mental process between the particular thoughts and the moral emotions. How would the view be darkened or confused, or indeed in any degree changed, by withdrawing that process, or erasing the words which attempt to express it? No advocate of the *intellectual origin of the moral faculty* has yet stated a case in which a mere operation of reason or judgment, unattended by emotion, could, consistently with the universal opinion of mankind, as it is exhibited by the structure of language, be said to have the nature or to produce the effects of Conscience. Such an example would be equivalent to an *experimentum crucis* on the side of that celebrated theory. The failure to produce it, after long challenge, is at least a presumption against it, nearly approaching to that sort of decisively discriminative experiment. It would be vain to restate what has already been too often repeated, that all the objections to the selfish philosophy turn upon the actual nature, not upon the original source of our principles of action; and that it is by a confusion of these very distinct questions alone that the confutation of Hobbes can be made apparently to involve Hartley. Mr Stewart appears, like most other metaphysicians, to have blended the inquiry into the nature of our moral sentiments with that other which only seeks a criterion to distinguish moral from immoral habits of feeling and action; for he considers the appearance of moral sentiment at an early age, before the general tendency of actions could be ascertained, as a decisive objection to the origin of these sentiments in association,—an objection which assumes that, if utility be the criterion of morality, associations with utility must be the mode by which the moral sentiments are formed, which no skilful advocate of the theory of association will ever allow. That the main, if not sole object of conscience is to govern our voluntary exertions, is manifest. But how could it perform this great function if it did not impel the will? and how could it have the latter effect as a mere act of reason, or indeed in any respect otherwise than as it is made up of emotions, by which alone its grand aim could in any degree be attained? Judgment and reason are therefore preparatory to conscience, not properly a part of it. That the exclusion of reason reduces virtue to be a relative quality, is another instance of the confusion of the two questions in moral theory; for though a fitness to excite approbation may be only a relation of objects to our susceptibility, yet the proposition that all virtuous actions are beneficial, is a proposition as absolute as any other within the range of our understanding.

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[1] *Elements of the Philosophy of the Human Mind*, vol. I. p. 340–352.

[2] *Ibid.* vol. I. p. 502.

[3] *Ibid.* vol. II. p. 57.

[4] Edinburgh, 1794, 8vo.

[5] P. 76–148.

[6] Two vols. 8vo. Edinburgh, 1828.

A delicate state of health, and an ardent desire to devote himself exclusively to study and composition, induced Mr Stewart, while in the full blaze of his reputation as a lecturer, to retire, in 1810, from the labour of public instruction. This retirement, as he himself describes it, was that of a quiet but active life. Three quarto and two octavo volumes, besides the magnificent Dissertations prefixed to this Encyclopædia, were among its happy fruits. These Dissertations are, perhaps, the most profusely ornamented of any of his compositions; a peculiarity which must in part have arisen from a principle of taste, which regarded decoration as more suitable to the history of philosophy than to philosophy itself. But the memorable instances of Cicero, of Milton, and still more those of Dryden and Burke, seem to show that there is some natural tendency in the fire of genius to burn more brightly or to blaze more fiercely in the evening than in the morning of human life. Probably the materials which long experience supplies to the imagination, the boldness with which a more established reputation arms the mind, and the silence of the low but formidable rivals of the higher principles, may concur in producing this unexpected and little observed effect.

It was in the last years of his life, when suffering under the effects of a severe attack of palsy, with which he had been afflicted in 1822, that Mr Stewart most plentifully reaped the fruits of long virtue and a well-ordered mind. Happily for him, his own cultivation and exercise of every kindly affection had laid up for him a store of that domestic consolation which none who deserve it ever want, and for the loss of which, nothing beyond the threshold can make amends. The same philosophy which he had cultivated from his youth upward employed his dying hand. Aspirations after higher and brighter scenes of excellence, always blended with his elevated morality, became more earnest and deeper as worldly passions died away, and earthly objects vanished from his sight.

THOMAS BROWN.[1]

A WRITER, as he advances in life, ought to speak with diffidence of systems which he had only begun to consider with care after the age in which it becomes hard for his thoughts to flow into new channels. A reader cannot be said practically to understand a theory, till he has acquired the power of thinking, at least for a short time, with the theorist. Even a hearer, with all the helps of voice in the instructor, of countenance from him and from fellow-hearers, finds it difficult to perform this necessary process without either being betrayed into hasty and undistinguishing assent, or falling, while he is in pursuit of an impartial estimate of opinions, into an indifference about their truth. I have felt this difficulty in reconsidering ancient opinions: but it is perhaps more needful to own its power, and to warn the reader against its effects, in the case of a philosopher well known to me, and with whom common friendships stood in the stead of much personal intercourse, as a cement of kindness.

I very early read Brown's *Observations on the Zoonomia* of Dr Darwin, the perhaps unmatched work of a boy in the eighteenth year of his age.[2] His first tract on *Causation* appeared to me the finest model of discussion in mental philosophy since Berkeley and Hume; with this superiority over the latter, that its aim is that of a philosopher who seeks to enlarge knowledge, not that of a sceptic, the most illustrious of whom have no better end than that of displaying their powers in confounding and darkening every truth; so that their very happiest efforts cannot be more leniently described than as brilliant fits of mental debauchery.[3] From a diligent perusal of his succeeding works at the time of their publication, I was prevented by pursuits and duties of a very different nature. These causes, together with ill health and growing occupation, hindered me from reading his *Lectures* with due attention, till it has now become a duty to consider with care that part of them which relates to Ethics.

Dr Brown was born in one of those families of ministers in the Scottish church who, after a generation or two of a humble life spent in piety and usefulness, with no more than needful knowledge, have more than once sent forth a man of genius from their cool and quiet shade, to make his fellows wiser or better by tongue or pen, by head or hand. Even the scanty endowments and constant residence of that church, by keeping her ministers far from the objects which awaken turbulent passions and disperse the understanding on many pursuits, afforded some of the leisure and calm of monastic life, without the exclusion of the charities of family and kindred. It may be well doubted whether this undissipated retirement, which during the eighteenth century was very general in Scotland, did not make full amends for the loss of curious and ornamental knowledge, by its tendency to qualify men for professional duty, by the cultivation of reason among a considerable number, and by those opportunities for high meditation, and for the unchangeable concentration of mind on worthy objects, to the few who had the natural capacity for such exertions.[1]

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[1] Born in 1778; died in 1820.

[2] WELSH's *Life of Brown*, p. 43; a pleasingly affectionate work, full of analytical spirit and metaphysical reading,—of such merit, in short, that I could wish to have found in it no phrenology. Objections *a priori* in a case dependent on facts are indeed inadmissible. Even the allowance of presumptions of that nature would open so wide a door for prejudices, that at most they can be considered only as maxims of logical prudence, which fortify the watchfulness of the individual. The fatal objection to phrenology seems to me to be, that what is new in it, or peculiar to it, has no approach to an adequate foundation in experience.

[3] "Bayle, a writer who, pervading human nature at his ease, struck into the province of paradox as an exercise for the unwearied vigour of his mind; who, with a soul superior to the sharpest attacks of fortune, and a heart practised to the best philosophy, had not enough of real greatness to overcome that last foible of superior minds. the temptation of honour which the academic exercise of wit is conceived to bring to its professor." So Warburton (*Divine Legation*, book i. sect. 4), speaking of Bayle, but perhaps in part excusing himself—in a noble strain, of which it would have been more agreeable to find the repetition than the contrast in his language towards Hume.

An authentic account of the early exercises of Brown's mind is preserved by his biographer.[2] At the age of nineteen he took a part with others, some of whom became the most memorable men of their time, in the foundation of a private society in Edinburgh, under the name of "the Academy of Physics."[3]

The character of Dr Brown is very attractive, as an example of one in whom the utmost tenderness of affection, and the indulgence of a flowery fancy, were not repressed by the highest cultivation, and by a perhaps excessive refinement of intellect. His mind soared and roamed through every region of philosophy and poetry; but his untravelled heart clung to the hearth of his father, to the children who shared it with him, and after them, first to the other partners of his childish sports, and then almost solely to those companions of his youthful studies who continued to be the friends of his life. Speculation seemed to keep his kindness at home. It is observable, that though sparkling with fancy, he does not seem to have been deeply or durably touched by those affections which are lighted at its torch, or at least tinged with its colours. His heart sought little abroad, but contentedly dwelt in his family and in his study. He was one of those men of genius who repaid the tender care of a mother by rocking the cradle of her reposing age. He ended a life spent in searching for truth, and exercising love, by desiring that he should be buried in his native parish, with his "dear father and mother." Some of these delightful qualities were perhaps hidden from the casual observer in general society, by the want of that perfect simplicity of manner which is doubtless their natural representative. Manner is a better mark of the state of a mind, than those large and deliberate actions which form what is called conduct. It is the constant and insensible transpiration of character. In serious acts a man may display himself. In the thousand nameless acts which compose manner, the mind betrays its habitual bent. But manner is then only an index of disposition, when it is that of men who live at ease in the intimate familiarity of friends and equals. It may be diverted from simplicity by causes which do not reach so deep as the character; by bad models, or by a restless and wearisome anxiety to shine, arising from many circumstances, none of which are probably more common than the unseasonable exertions of a recluse student in society, and the unfortunate attempts of some others, to take by violence the admiration of those with whom they do not associate with ease. The association with unlike or superior companions which least distorts manners, is that which takes place with those classes whose secure dignity generally renders their own manners easy; with whom the art of pleasing or of not displeasing each other in society is a serious concern; who have leisure enough to discover the positive and negative parts of the smaller moralities; and who, being trained to a watchful eye on what is ludicrous, apply the lash of ridicule to affectation, the most ridiculous of faults. The busy in every department of life are too respectably occupied to form these manners or to bestow them. They are the frivolous work of polished idleness; and perhaps their most serious value consists in the war which they wage against affectation; though even there they betray their nature in punishing it, not as a deviation from nature, but as a badge of vulgarity.

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[1] See Sir H. Moncreiff's *Life of the Reverend Dr Erskine.*

[2] Welsh's *Life of Brown*, p. 77, and App. p. 498.

[3] A part of the first day's minutes is here borrowed from Mr Welsh:—"7th January 1797.—Present, Mr Erskine, President,—Mr Brougham, Mr Reddie, Mr Brown, Mr Birbeck, Mr Leyden," &c. who were afterwards joined by Lord Webb Seymour, Messrs Horner, Jeffrey, Smyth, &c. Mr Erskine, who thus appears at the head of so remarkable an association, and whom diffidence and untoward circumstances have hitherto withheld from the full manifestation of his powers, continued to be the bosom friend of Brown to the last, and showed the constancy of his friendship for others by converting all his invaluable preparations for a translation of Sultan Baber's *Commentaries* (perhaps the best, certainly the most European work of modern eastern prose) into the means of completing the imperfect attempt of Leyden; with a regard equally generous to the fame of his early friend, and to the comfort of that friend's surviving relations. The review of Baber's *Commentaries*, by M. Silvestre de Sacy, in the *Journal des Savans* for May and June 1829, is perhaps one of the best specimens extant of the value of literary commendation when it is bestowed with conscientious calmness, and without a suspicion of bias, by one of the greatest orientalists, in a case where he pronounces every thing to have been done by Mr Erskine "which could have been performed by the most learned and the most scrupulously conscientious of editors and translators."

The prose of Dr Brown is brilliant to excess. It must not be denied that its beauty is sometimes womanly; that it too often melts down precision into elegance; that it buries the main idea under a load of illustration, of which every part is expanded and adorned with such a visible labour, as to withdraw the mind from attention to the thoughts which it professes to introduce more easily into the understanding. It is darkened by excessive brightness; it loses ease and liveliness by over-dress; and, in the midst of its luscious sweetness, we wish for the striking and homely illustrations of Tucker, and for the pithy and sinewy sense of Paley, either of whom, by a single short metaphor from a familiar, perhaps a low object, could at one blow set the two worlds of reason and fancy in movement.

It would be unjust to censure severely the declamatory parts of his Lectures; they are excusable in the first warmth of composition. They might even be justifiable allurements in attracting young hearers to abstruse speculations. Had he lived, he would probably have taken his thoughts out of the declamatory forms of spoken address, and given to them the appearance, as well as the reality, of deep and subtile discussion. The habits indeed of so successful a lecturer, and the natural luxuriancy of his mind, could not fail to have somewhat tinctured all his compositions; but though he might still have fallen short of simplicity, he certainly would have avoided much of the diffusion, and even common-place, which hang heavily on original and brilliant thoughts; for it must be owned, that though, as a thinker, he is unusually original, yet when he falls among the declaimers, he is infected by their common-places.

In like manner, he would assuredly have shortened or left out many of the poetical quotations which he loved to recite, and which hearers even beyond youth hear with delight. There are two very different sorts of passages of poetry to be found in works on philosophy, which are as far asunder from each other in value as in matter. A philosopher will admit some of those wonderful lines or words which bring to light the infinite varieties of character, the furious bursts or wily workings of passion, the winding approaches of temptation, the slippery path to depravity, the beauty of tenderness, the grandeur of what is awful and holy in man. In every such quotation, the moral philosopher, if he be successful, uses the best materials of his science; for what are they but the results of experiment and observation on the human heart, performed by artists of far other skill and power than his? They are facts which could have only been ascertained by Homer, by Dante, by Shakspeare, by Cervantes, by Milton. Every year of admiration since the unknown period when the Iliad first gave delight, has extorted new proofs of the justness of the picture of human nature, from the responding hearts of the admirers. Every strong feeling which these masters have excited is a successful repetition of their original experiment, and a continually growing evidence of the greatness of their discoveries. Quotations of this nature may be the most satisfactory, as well as the most delightful, proofs of philosophical positions. Others of inferior merit are not to be interdicted: a pointed maxim, especially when familiar, pleases, and is recollected. I cannot entirely conquer my passion for the Roman and Stoical declamation of some passages in Lucan and Akenside. But quotations from those who have written on philosophy in verse, or, in other words, from those who generally are inferior philosophers, and voluntarily deliver their doctrines in the most disadvantageous form, seem to be unreasonable. It is agreeable, no doubt, to the philosopher, still more to the youthful student, to meet his abstruse ideas clothed in the sonorous verse of Akenside. The surprise of the unexpected union of verse with science is a very lawful enjoyment. But such slight and momentary pleasures, though they may tempt the writer to display them, do not excuse a vain effort to obtrude them on the sympathy of the searcher after truth in after-times. It is peculiarly unlucky that Dr Brown should have sought supposed ornament from the moral common-places of Thomson, rather than from that illustration of philosophy which is really to be found in his picturesque strokes.

Much more need not be said of Dr Brown's own poetry, somewhat voluminous as it is, than that it indicates fancy and feeling, and rose at least to the rank of an elegant accomplishment. It may seem a paradox, but it appears to me that he is really most poetical in those poems and passages which have the *most properly metaphysical* character. For every various form of life and nature, when it is habitually contemplated, may inspire feeling; and the just representation of these feelings may be poetical. Dr Brown observed man, and his wider world, with the eye of a metaphysician; and the dark results of such contemplations, when he reviewed them, often filled his soul with feelings which, being both grand and melancholy, were truly poetical. Unfortunately, however, few readers can be touched with fellow-feeling. He sings to few, and must be content with sometimes moving a string in the soul of the lonely visionary, who, in the day-dreams of youth, has felt as well as meditated on the mysteries of nature. His heart has produced charming passages in all his poems; but, generally speaking, they are only beautiful works of art and imitation. The choice of Akenside as a favourite and a model may, without derogation from that writer, be considered as no proof of a poetically formed mind.[1] There is more poetry in many single lines of Cowper than in volumes of sonorous verses such as Akenside's. Philosophical poetry is very different from versified philosophy. The former is the highest exertion of genius, the latter cannot be ranked above the slighter amusements of ingenuity. Dr Brown's poetry was, it must be owned, composed either of imitations, which, with some exceptions, may be produced and read without feeling, or of effusions of such feelings only as meet a rare and faint echo in the human breast.

A few words only can here be bestowed on the intellectual part of his philosophy. It is an open revolt against the authority of Reid; and, by a curious concurrence, he began to lecture nearly at the moment when the doctrines of that philosopher came to be taught with applause in France. Mr Stewart had dissented from the language of Reid, and had widely departed from his opinions on several secondary theories. Dr Brown rejected them entirely. He very justly considered the claim of Reid to the merit of detecting the universal delusion which had betrayed philosophers into the belief that ideas which were the sole objects of knowledge had a separate existence, as a proof of his having mistaken their illustrative language for a metaphysical opinion;[2] but he does not do justice to the service which Reid really rendered to mental science, by keeping the attention of all future speculators in a state of more constant watchfulness against the transient influence of such an illusion. His choice of the term *feeling*[3] to denote the operations which we usually refer to the understanding, is evidently too wide a departure from its ordinary use, to have any probability of general adoption. No definition can strip so familiar a word of the thoughts and emotions which have so long accompanied it, so as to fit it for a technical term of the highest abstraction. If we can be said to have a feeling "of the equality of the angle of forty-five degrees to half the angle of ninety degrees,"[1] we may call Geometry and Arithmetic sciences of feeling. He has very forcibly stated the necessity of assuming "*the primary universal intuitions of direct belief*," which, in their nature, are incapable of all proof. They seem to be accurately described as notions which cannot be conceived separately, but without which nothing can be conceived. They are not only necessary to reasoning and to belief, but to thought itself. It is equally impossible to prove or to disprove them. He has very justly blamed the school of Reid for "an extravagant and ridiculous" multiplication of those principles which he truly represents as inconsistent with sound philosophy. To philosophize is indeed nothing more than to simplify securely.[2]

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[1] His accomplished friend Mr Erskine confesses that Brown's poems "are not written in the language of plain and gross emotion. The string touched is too delicate for general sympathy. They are in an unknown tongue to one half" (he might have said nineteen twentieths) "of the reading part of the community." (Welsh's *Life of Brown*, p. 431.)

[2] Brown's *Lectures*, vol. II. p. 1–49.

[3] *Ibid.* vol. I. p. 220, &c.

The substitution of *suggestion* for the former phrase, *association of ideas*, would hardly deserve notice in so cursory a view, if it had not led him to a serious misconception of the doctrines and deserts of other philosophers. The fault of the latter phrase is rather in the narrowness of the last, than in the inadequacy of the first word. *Association* presents the fact in the light of a *relation* between two mental acts. *Suggestion* denotes rather the *power* of the one to call up the other. But whether we say that the sight of ashes suggests fire, or that the ideas of fire and ashes are associated, we mean to convey the same fact; and, in both cases, an exact thinker means to accompany the fact with no hypothesis. Dr Brown has supposed the word *association* as intended to affirm that there was some "intermediate process"[3] between the original succession of the mental acts, and the power which they acquired therefrom of calling up each other. This is quite as much to raise up imaginary antagonists for the honour of conquering them, as he justly reprehends Dr Reid for doing in the treatment of preceding philosophers. He falls into another more important and unaccountable error, in representing his own reduction of Mr Hume's principles of association (resemblance, contrariety, causation, contiguity in time or place) to the one principle of contiguity, as a discovery of his own, by which his theory is distinguished from "the universal opinion of philosophers."[4] Nothing but too exclusive a consideration of the doctrines of the Scottish school could have led him to speak thus of what was hinted by Aristotle, distinctly laid down by Hobbes, and fully unfolded both by Hartley and Condillac. He has, however, extremely enlarged the proof and the illustration of this law of mind, by the exercise of "a more subtile analysis," and the disclosure of "a finer species of proximity."[5] As he has thus aided and confirmed, though he did not discover the general law, so he has rendered a new and very important service to mental science, by what he properly calls "secondary laws of suggestion"[6] or association,—circumstances which modify the action of the general law, and must be distinctly considered, in order to explain its connection with the phenomena. The enumeration and exposition are instructive, and the example is worthy of commendation. For it is in this lower region of science that most remains to be discovered; it is that which rests most on observation, and least tempts to controversy; it is by improvements in that part of knowledge that the foundations are secured, and the whole building so repaired as to rest steadily on them. The distinction of common language between the head and the heart, which, as we have seen, is so often overlooked or misapplied by metaphysicians, is, in the system of Brown, signified by the terms "mental states" and "emotions." It is unlucky that no single word could be found for the former, and that the use of "feeling," as the generic term, should disturb its easy comprehension when it is applied more naturally.

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[1] Brown's *Lectures*, vol. I. p. 222.

[2] Dr Brown always expresses himself best where he is short and familiar. "An hypothesis is nothing more than a reason for making one experiment or observation rather than another." (*Lectures*, vol. I. p. 170.) In 1812, as the present writer observed to him that Reid and Hume differed more in words than in opinion, he answered, "Yes. Reid bawled out, we must believe an outward world; but added in a whisper, we can give no reason for our belief. Hume cries out, we can give no reason for such a notion; and whispers, I own we cannot get rid of it."

[3] *Lectures*, vol. II. p. 335–347. [4] *Ibid.* vol. II. p. 349. [5] *Ibid.* vol. II. p. 218, &c. [6] *Ibid.* vol. II. p. 270.

In our more proper province he has followed Butler, who appears to have been chiefly known to him through Mr Stewart, in the theory of the social affections. Their disinterestedness is enforced by the arguments of both these philosophers, as well as of Hutcheson.[1] It is observable, however, that he applies the principle of suggestion or association boldly to this part of human nature, and seems inclined to refer to it even sympathy itself.[2] It is hard to understand how, with such a disposition on the subject of a principle so generally thought ultimate as *Sympathy*, he should, inconsistently with himself, follow Mr Stewart in representing the theory which derives the affections from association as "*a Modification of the Selfish System*."[3] He mistakes that theory by stating, that it derives the affections from our experience that our own interest was connected with that of others; while in truth it considers our regard to our own interest as formed from the same original pleasures by association, which, by the like process, may and do *directly* generate affections towards others, without passing through the channel of regard to our general happiness. But, says he, this is only an hypothesis, since the formation of these affections is acknowledged to belong to a time of which there is no remembrance;[4]—an objection fatal to every theory of any mental function,—subversive, for example, of Berkeley's discovery of acquired visual perception, and most strangely inconsistent in the mouth of a philosopher whose numerous simplifications of mental theory are and must be founded on occurrences which precede experience. It is in all other cases, and it must be in this, sufficient that the principle of the theory is really existing, that it explains the appearances, that its supposed action *resembles* what we know to be its action in those similar cases of which we have direct experience. Lastly, he in express words admits that, according to the theory to which he objects, we have affections which are at present disinterested.[5] Is it not a direct contradiction in terms to call such a theory "a modification of the selfish system?" His language in the sequel clearly indicates a distrust of his own statement, and a suspicion that he is not only inconsistent, but altogether mistaken.[6]

As we enter more deeply into the territory of Ethics, we at length discover in Brown a distinction, the neglect of which by preceding speculators we have more than once lamented as productive of obscurity and confusion:—"The moral affections," says he, "which I consider at present, I consider rather physiologically" (or, as he elsewhere better expresses it, "psychologically") "than ethically, *as parts of our mental constitution*, not as involving the *fulfilment or violation of duties*."[7] He immediately, however, loses sight of this distinction, and reasons inconsistently with it, instead of following it to its proper consequences in his explanation of conscience. Perhaps, indeed, (for the words are capable of more than one sense,) he meant to distinguish the virtuous affections from those sentiments which have morality exclusively in view, rather than to distinguish the theory of moral sentiment from the attempt to ascertain the characteristic quality of right action. Friendship is conformable in its dictates to morality; but it may, and does exist, without any view to it. He who feels the affections, and performs the duties of friendship, is the object of that distinct emotion which is called moral approbation.

It is on the subject of conscience that, in imitation of Mr Stewart, and with no other arguments than his, he makes his chief stand against the theory which considers the formation of that master faculty itself as probably referable to the necessary and universal operation of those laws of human nature to which he himself ascribes almost every other state of mind. On both sides of this question the supremacy of conscience is alike held to be venerable and absolute. Once more, be it remembered, that the question is purely philosophical, and is only whether, from the impossibility of explaining its formation by more general laws, we are reduced to the necessity of considering it as an original fact in human nature, of which no further account can be given. Let it, however, be also remembered, that we are not driven to this supposition by the mere circumstance, that no satisfactory explanation has yet appeared; for there are many analogies in an unexplained state of mind to states already explained, which may justify us in believing that the explanation requires only more accurate observation, and more patient meditation, to be brought to that completeness which it probably will attain.

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[1] Brown's *Lectures*, vol. III. p. 248.

[2] *Ibid.* vol. III. p. 282.

[3] *Ibid.* vol. IV. p. 82, *et seq.*

[4] *Ibid.* vol. IV. p. 87.

[5] *Ibid.* vol. IV. p. 87.

[6] *Ibid.* vol. IV. p. 94–97.

[7] *Ibid.* vol. III. p. 231.

SECTION VII.

GENERAL REMARKS.

Having thus again premised an already often repeated warning, it remains that we should offer a few observations on the questions so understood, which naturally occur on the consideration of Dr Brown's argument in support of the proposition, that moral approbation is not only in its mature state independent of and superior to any other principle of human nature, regarding which there is no dispute, but that its origin is altogether inexplicable, and that its existence is an ultimate fact in mental science. Though these observations are immediately occasioned by the perusal of Brown, they are yet, in the main, of a general nature, and might have been made without reference to any particular writer.

The term *Suggestion*, which might be inoffensive in describing merely intellectual associations, becomes peculiarly unsuitable when it is applied to those combinations of thought with emotion, and to those unions of feeling, which compose the emotive nature of man. Its common sense of a sign *recalling* the thing signified, always embroils the new sense vainly forced upon it. No one can help owning, that if it were consistently pursued, so as that we were to speak of *suggesting a feeling or passion*, the language would be universally thought absurd. To suggest love or hatred is a mode of expression so manifestly incongruous, that most readers would choose to understand it as suggesting reflections on the subject of these passages. *Suggest* would not be understood by any common reason as synonymous with *revive* or *rekindle*. Defects of the same sort may indeed be found in the parallel phrases of most if not all philosophers, and all of them proceed from the same source,—namely, the erroneous but prevalent notion, that the law of association produces only such a close union of a thought and a feeling, as gives one the power of reviving the other; instead of the truth, that it forms them into a new compound, in which the properties of the component parts are no longer discoverable, and which may itself become a substantive principle of human nature. They supposed the condition, produced by its power, to resemble that of material substances in a state of mechanical diffusion; whereas in reality it may be better likened to a chemical combination of the same substances, from which a totally new product arises. The language involves a confusion of the question which relates to the *origin* of the principles of human activity, with the other and far more important question which relates to their *nature;* and as soon as this distinction is hidden, the theorist is either betrayed into the selfish system by a desire of clearness and simplicity, or tempted to the needless multiplication of ultimate facts by mistaken anxiety for what he supposes to be the guards of our social and moral nature. The defect is common to Brown with his predecessors, but in him less excusable; for he saw the truth and recoiled from it.

It is the main defect of the term *association* itself, that it does not, without long habit, convey the notion of a perfect union, but rather leads to that of a combination which may be dissolved, if not at pleasure, at least with the help of care and exertion; which is utterly and dangerously false in the important cases where such unions are considered as constituting the most essential principles of human nature. Men can no more dissolve these unions than they can disuse their habit of judging of distance by the eye, and often by the ear. But *suggestion* implies, that what suggests is separate from what is suggested, and consequently negatives that unity in an active principle which the whole analogy of nature, as well as our own direct consciousness, shows to be perfectly compatible with its origin in composition.

Large concessions are, in the first place, to be remarked, which must be stated, because they very much narrow the matter in dispute. Those who, before Brown, contended against beneficial tendency as the standard of morality, have either shut their eyes on the connection of virtue with general utility; or carelessly and obscurely allowed, without further remark, a connection which is at least one of the most remarkable and important of ethical facts. He acts more boldly, and avowedly discusses "the relation of virtue to utility." He was compelled by that discussion to make those concessions which so much abridge this controversy. "Utility and virtue are so related, that there is perhaps no action generally felt to be virtuous, which it would not be beneficial that all men in similar circumstances should imitate."[1] "In every case of benefit or injury willingly done, there arise certain emotions of moral approbation or disapprobation."[2] "The intentional produce of evil, as pure evil, is always hated; and that of good, as pure good, always loved."[3] All virtuous acts are thus admitted to be universally beneficial; morality and the general benefit are acknowledged always to coincide. It is hard to say, then, why they should not be reciprocally tests of each other, though in a very different way;—the virtuous feelings, fitted as they are by immediate appearance, by quick and powerful action, being sufficient tests of morality in the moment of action, and for all practical purposes; while the consideration of tendency to general happiness, a more obscure and slowly discoverable quality, should be applied in general reasoning, as a test of the sentiments and dispositions themselves. It has been thus employed, and no proof has been attempted, that it has ever deceived those who used it in the proper place. It has uniformly served to justify our moral constitution, and to show how reasonable it is for us to be guided in action by our higher feelings. At all events it should be, but has not been considered, that from these concessions alone it follows, that beneficial tendency is at least one constant property of virtue. Is not this, in effect, an admission that beneficial tendency does distinguish virtuous acts and dispositions from those which we call vicious? If the criterion be incomplete or delusive, let its faults be specified, and let some other quality be pointed out, which, either singly or in combination with beneficial tendency, may more perfectly indicate the distinction.

But let us not be assailed by arguments which leave untouched its value as a test, and are in truth directed only against its fitness as an *immediate* incentive and guide to right action. To those who contend for its use in the latter character, it must be left to defend, if they can, so untenable a position. But all others must regard as pure sophistry the use of arguments against it as a test, which really show nothing more than its acknowledged unfitness to be a motive.

When voluntary benefit and voluntary injury are pointed out as the main, if not the sole objects of moral approbation and disapprobation,—when we are told truly, that the production of good, as good, is always loved, and that of evil, as such, always hated,—can we require a more clear, short, and unanswerable proof, that beneficial tendency is an essential quality of virtue? It is indeed an evidently necessary consequence of this statement, that if benevolence be amiable in itself, our affection for it must increase with its extent; and that no man can be in a perfectly right state of mind, who, if he consider general happiness at all, is not ready to acknowledge that a good man must regard it as being in its own nature the most desirable of all objects, however the constitution and circumstances of human nature may render it unfit or impossible to pursue it *directly* as the object of life. It is at the same time apparent that no such man can consider any habitual disposition, clearly discerned to be in its whole result at variance with general happiness, as not unworthy of being cultivated, or as not fit to be rooted out. It is manifest that, if it were otherwise, he would cease to be benevolent. As soon as we conceive the sublime idea of a Being who not only foresees, but commands, all the consequences of the actions of all voluntary agents, this scheme of reasoning appears far more clear. In such a case, if our moral sentiments remain the same, they compel us to attribute his whole government of the world to benevolence. The consequence is as necessary as in any process of reason; for if our moral nature be supposed, it will appear self-evident, that it is as much impossible for us to love and revere such a Being, if we ascribe to him a mixed or imperfect benevolence, as to believe the most positive contradiction in terms. Now, as religion consists in that love and reverence, it is evident that it cannot subsist without a belief in benevolence as the sole principle of divine government. It is nothing to tell us that this is not a process of reasoning, or, to speak more exactly, that the first propositions are assumed. The first propositions in every discussion relating to intellectual operations must likewise be assumed. Conscience is not reason, but it is not less an essential part of human nature than reason. Principles which are essential to all its operations are as much entitled to immediate and implicit assent, as those principles which stand in the same relation to the reasoning faculties. The laws prescribed by a benevolent Being to his creatures must necessarily be founded on the principle of promoting their happiness. It would be singular indeed, if the proofs of the goodness of God, legible in every part of nature, should not, above all others, be most discoverable and conspicuous in the beneficial tendency of his moral laws.

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[1] *Lectures*, vol. IV. p. 45. The unphilosophical word "perhaps" must be struck out of the proposition, unless the whole be considered as a mere conjecture. It limits no affirmation, but destroys it, by converting it into a guess. See the like concession, vol. IV. p. 33, with some words interlarded, which betray a sort of reluctance and fluctuation, indicative of the difficulty with which Brown struggled to withhold his assent from truths which he unreasonably dreaded.

[2] *Ibid.* vol. III. p. 567.

[3] *Ibid.* vol. III. p. 621.

But we are asked, if tendency to general welfare be the standard of virtue, why is it not always present to the contemplation of every man who does or prefers a virtuous action? Must not utility be in that case "the felt essence of virtue?"[1] Why are other ends, besides general happiness, fit to be morally pursued?

These questions, which are all founded on that confusion of the *theory of actions* with the theory of *sentiments*, against which the reader was so early warned,[2] might be dismissed with no more than a reference to that distinction from the forgetfulness of which they have arisen. By those advocates of utility, indeed, who hold it to be a necessary part of their system, that some glimpse at least of tendency to personal or general wellbeing is an essential part of the motives which render an action virtuous, these questions cannot be satisfactorily answered. Against such they are arguments of irresistible force; but against the doctrine itself, rightly understood and justly bounded, they are altogether powerless. The reason why there may, and must be, many ends morally more fit to be pursued in practice than general happiness, is plainly to be found in the limited capacity of man. A perfectly good Being, who foresees and commands all the consequences of action, cannot indeed be conceived by us to have any other end in view than general wellbeing Why evil exists under that perfect government, is a question towards the solution of which the human understanding can scarcely advance a single step. But all who hold the evil to exist only for good, and own their inability to explain why or how, are perfectly exempt from any charge of inconsistency in their obedience to the dictates of their moral nature. The measure of the faculties of man renders it absolutely necessary for him to have many other practical ends; the pursuit of all of which is moral, when it actually tends to general happiness, though that last end never entered into the contemplation of the agent. It is impossible for us to calculate the effects of a single action, any more than the chances of a single life. But let it not be hastily concluded, that the calculation of consequences is impossible in moral subjects. To calculate the general tendency of every sort of human action, is a possible, easy, and common operation. The general good effects of temperance, prudence, fortitude, justice, benevolence, gratitude, veracity, fidelity,—of the affections of kindred, and of love for our country,—are the subjects of calculations which, taken as generalities, are absolutely unerring. They are founded on a larger and firmer basis of more uniform experience, than any of those ordinary calculations which govern prudent men in the whole business of life. An appeal to these daily and familiar transactions furnishes at once a decisive answer, both to those advocates of utility who represent the consideration of it as a necessary ingredient in virtuous motives, as well as moral approbation, and to those opponents who turn the unwarrantable inferences of unskilful advocates into proofs of the absurdity into which the doctrine leads.

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[1] *Lectures*, vol. IV. p. 38.

[2] See *supra*, p. 313-315.

The cultivation of all the habitual sentiments from which the various classes of virtuous actions flow—the constant practice of such actions—the strict observance of rules in all that province of Ethics which can be subjected to rules—the watchful care of all the outworks of every part of duty, of that descending series of useful habits which, being securities to virtue, become themselves virtues,—are so many ends which it is absolutely necessary for man to pursue and to seek for their own sake.

"I saw D'Alembert," says a very late writer, "congratulate a young man very coldly, who brought him a solution of a problem. The young man said, 'I have done this in order to have a seat in the Academy.' 'Sir,' answered D'Alembert, 'with such dispositions you never will earn one. Science must be loved for its own sake, and not for the advantage to be derived. No other principle will enable a man to make progress in the sciences.'"[1] It is singular that D'Alembert should not perceive the extensive application of this truth to the whole nature of man. No man can make progress in a virtue who does not seek it for its own sake. No man is a friend, a lover of his country, a kind father, a dutiful son, who does not consider the cultivation of affection and the performance of duty in all these cases respectively as incumbent on him for their own sake, and not for the advantage to be derived from them. Whoever serves another with a view of advantage to himself is universally acknowledged not to act from affection. But the more immediate application of this truth to our purpose is, that in the case of those virtues which are the means of cultivating and preserving other virtues, it is necessary to acquire love and reverence for the secondary virtues for their own sake, without which they never will be effectual means of sheltering and strengthening those intrinsically higher qualities to which they are appointed to minister. Every moral act must be considered as an end, and men must banish from their practice the regard to the most naturally subordinate duty as a means. Those who are perplexed by the supposition that secondary virtues, making up by the *extent* of their beneficial tendency for what in each particular instance they may want in *magnitude*, may become of as great importance as the primary virtues themselves, would do well to consider a parallel though very homely case. A house is useful for many purposes: many of these purposes are in themselves, for the time, more important than shelter. The destruction of the house may, nevertheless, become a greater evil than the defeat of several of these purposes, because it is permanently convenient, and indeed necessary to the execution of most of them. A floor is made for warmth, for dryness—to support tables, chairs, beds, and all the household implements which contribute to accommodation and to pleasure. The floor is valuable only as a means; but, as the only means by which many ends are attained, it may be much more valuable than some of them. The table might be, and generally is, of more valuable timber than the floor; but the workman who should for that reason take more pains in making the table strong than the floor secure would not long be employed by customers of common sense. The connection of that part of morality which regulates the intercourse of the sexes with benevolence, affords the most striking instance of the very great importance which may belong to a virtue, in itself secondary, but on which the general cultivation of the highest virtues permanently depends. Delicacy and modesty may be thought chiefly worthy of cultivation, because they guard purity; but they must be loved for their own sake, without which they cannot flourish. Purity is the sole school of domestic fidelity, and domestic fidelity is the only nursery of the affections between parents and children, from children towards each other, and, through these affections, of all the kindness which renders the world habitable. At each step in the progress, the appropriate end must be loved for its own sake; and it is easy to see how the only means of sowing the seeds of benevolence, in all its forms, may become of far greater importance than many of the modifications and exertions even of benevolence itself. To those who will consider this subject, it will not long seem strange that the sweetest and most gentle affections grow up only under the apparently cold and dark shadow of stern duty. The obligation is strengthened, not weakened, by the consideration that it arises from human imperfection; which only proves it to be founded on the nature of man. It is enough that the pursuit of all these separate ends leads to general wellbeing, the promotion of which is the final purpose of the creation.

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[1] *Mémoires de Montlosier*, vol. I. p. 50.

The last and most specious argument against beneficial tendency, even as a test, is conveyed in the question, why moral approbation is not bestowed on every thing beneficial, instead of being confined, as it confessedly is, to voluntary acts. It may plausibly be said, that the establishment of the beneficial tendency of all those voluntary acts which are the objects of moral approbation is not sufficient, since, if such tendency be the standard, it ought to follow, that whatever is useful should also be morally approved. To answer, as has before been done,[1] that experience gradually limits moral approbation and disapprobation to voluntary acts, by teaching us that they influence the will, but are wholly wasted if they be applied to any other object,—though the fact be true, and contributes somewhat to the result, is certainly not enough. It is at best a partial solution. Perhaps, on reconsideration, it is entitled only to a secondary place. To seek a foundation for universal, ardent, early, and immediate feelings, in processes of an intellectual nature, has, since the origin of philosophy, been the grand error of ethical inquirers into human nature. To seek for such a foundation in association, an early and insensible process, which confessedly mingles itself with the composition of our first and simplest feelings, and which is common to both parts of our nature, is not liable to the same animadversion. If conscience be uniformly produced by the regular and harmonious co-operation of many processes of association, the objection is in reality a challenge to produce a complete theory of it, founded on that principle, by exhibiting such a full account of all these processes as may satisfactorily explain why it proceeds thus far and no farther. This would be a very arduous attempt, and perhaps it may be premature. But something may be more modestly tried towards an *outline*, which, though it might leave many particulars unexplained, may justify a reasonable expectation that they are not incapable of explanation; and may even now assign such reasons for the limitation of approbation to voluntary acts, as may convert the objection derived from that fact into a corroboration of the doctrines to which it has been opposed as an insurmountable difficulty. Such an attempt will naturally lead to the close of the present Dissertation. The attempt has indeed been already made,[1] but not without great apprehensions on the part of the author that he has not been clear enough, especially in those parts which appeared to himself to owe most to his own reflection. He will now endeavour, at the expense of some repetition, to be more satisfactory.

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[1] See *supra*, p. 372, 373.

There must be primary pleasures, pains, and even appetites, which arise from no prior state of mind, and which, if explained at all, can be derived only from bodily organization; for if there were not, there could be no secondary desires. What the number of the underived principles may be, is a question to which the answers of philosophers have been extremely various, and of which the consideration is not necessary to our present purpose. The rules of philosophizing, however, require that causes should not be multiplied without necessity. Of two explanations, therefore, which give an equally satisfactory account of appearances, that theory is manifestly to be preferred which supposes the smaller number of ultimate and inexplicable principles. This maxim, it is true, is subject to three indispensable conditions. 1. That the principles employed in the explanation should be known really to exist: in which consists the main distinction between hypothesis and theory. Gravity is a principle universally known to exist; ether and a nervous fluid are mere suppositions. 2. That these principles should be known to produce effects *like* those which are ascribed to them in the theory. This is a further distinction between hypothesis and theory; for there are an infinite number of degrees of *likeness*, from the faint resemblances which have led some to fancy that the functions of the nerves depend on electricity, to the remarkable coincidences between the appearances of projectiles on earth, and the movements of the heavenly bodies, which constitutes the Newtonian system; a theory now perfect, though exclusively founded on analogy, and in which one of the classes of phenomena brought together by it is not the subject of direct experience. 3. That it should correspond, if not with all the facts to be explained, at least with so great a majority of them as to render it highly probable that means will in time be found of reconciling it to all. It is only on this ground that the Newtonian system justly claimed the title of a legitimate theory during that long period when it was unable to explain many celestial appearances, before the labours of a century, and the genius of Laplace, at length completed the theory, by adapting it to all the phenomena. A theory may be just before it is complete.

In the application of these canons to the theory which derives most of the principles of human action from the transfer of a small number of pleasures, perhaps organic, by the law of association to a vast variety of new objects, it cannot be denied, 1*st*, That it satisfies the first of the above conditions, inasmuch as association is *really* one of the laws of human nature; 2*dly*, That it also satisfies the second, for association certainly produces effects *like* those which are referred to it by this theory, otherwise there would be no secondary desires, no acquired relishes and dislikes;—facts universally acknowledged, which are and can be explained only by the principle called by Hobbes *mental discourse;*—by Locke, Hume, Hartley, Condillac, and the majority of speculators, as well as in common speech, *association;*—by Tucker, *translation;*—and by Brown, *suggestion.* The facts generally referred to the principle *resemble* those which are claimed for it by the theory in this important particular, that in both cases equally, pleasure becomes attached to perfectly new things, so that the derivative desires become perfectly independent on the primary. The great dissimilarity of these two classes of passions has been supposed to consist in this, that the former always regards the interest of the individual, while the latter regards the welfare of others. The philosophical world has been almost entirely divided into two sects; the partisans of selfishness, comprising mostly all the predecessors of Butler, and the greater part of his successors; and the advocates of benevolence, who have generally contended that the reality of disinterestedness depends on its being a *primary principle.* Enough has been said by Butler against the more fatal heresy of selfishness. Something has already been said against the error of the advocates of disinterestedness, in the progress of this attempt to develope ethical truths historically, in the order in which inquiry and controversy brought them out with increasing brightness. The analogy of the material world is indeed faint, and often delusive; yet we dare not utterly reject that on which the whole technical language of mental and moral science is necessarily grounded. The whole creation teems with instances where the most powerful agents and the most lasting bodies are the acknowledged results of the composition, sometimes of a few, often of many elements. These compounds often in their turn become the elements of other substances; and it is with them that we are conversant chiefly in the pursuits of knowledge, solely in the concerns of life. No man ever fancied, that because they were compounds, they were therefore less *real.* It is impossible to confound them with any of the separate elements which contribute towards their formation. But a much more close resemblance presents itself. Every secondary desire, or acquired relish, involves in it a transfer of pleasure to something which was before indifferent or disagreeable. Is the new pleasure the less real for being acquired? Is it not often preferred to the original enjoyment? Are not many of these secondary pleasures indestructible? Do not many of them survive primary appetites? Lastly, the important principle of regard to our own general welfare, which disposes us to prefer it to immediate pleasure, unfortunately called self-love (as if, in any intelligible sense of the term *love*, it were possible for a man to love himself), is perfectly intelligible if its origin be ascribed to association, but utterly incomprehensible if it be considered as prior to the appetites and desires, which alone furnish it with materials. As happiness consists of satisfactions, self-love presupposes appetites and desires which are to be satisfied. If the order of time were important, the affections are formed at an earlier period than many self-regarding passions, and they always precede the formation of self-love.

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[1] See *supra*, p. 362–3, 381–5.

Many of the later advocates of the disinterested system, though recoiling from an apparent approach to the selfishness into which the purest of their antagonists had occasionally fallen, were gradually obliged to make concessions to the derivative system, though clogged with the contradictory assertion, that it was only a refinement of selfishness: and we have seen that Brown, the last and not the least in genius of them, has nearly abandoned the greater, though not indeed the most important part of the territory in dispute, and scarcely contends for any underived principle but the moral faculty.

In this state of opinion among the very small number in Great Britain who still preserve some remains of a taste for such speculations, it is needless here to trace the application of the law of association to the formation of the secondary desires, whether private or social. For our present purposes, the explanation of their origin may be assumed to be satisfactory. In what follows, it must, however, be steadily borne in mind, that this concession involves an admission that the pleasure derived from low objects may be transferred to the most pure; that from a part of a self-regarding appetite such a pleasure may become a portion of a perfectly disinterested desire; and that the disinterested nature and absolute independence of the latter are not in the slightest degree impaired by the consideration, that it is formed by one of those grand mental processes to which the formation of the other habitual states of the human mind have been, with great probability, ascribed.

When the social affections are thus formed, they are naturally followed in every instance by the will to do whatever can promote their object. Compassion excites a voluntary determination to do whatever relieves the person pitied. The like process must occur in every case of gratitude, generosity, and affection. Nothing so uniformly follows the kind disposition as the act of will, because it is the only means by which the benevolent desire can be gratified. The result of what Brown justly calls "a finer analysis," shows a mental contiguity of the affection to the volition to be much closer than appears on a coarser examination of this part of our nature. No wonder, then, that the strongest association, the most active power of reciprocal suggestion, should subsist between them. As all the affections are delightful, so the volitions, voluntary acts which are the only means of their gratification, become agreeable objects of contemplation to the mind. The habitual disposition to perform them is felt in ourselves, and observed in others, with satisfaction. As these feelings become more lively, the absence of them may be viewed in ourselves with a pain, in others with an alienation capable of indefinite increase. They become entirely independent sentiments; still, however, receiving constant supplies of nourishment from their parent affections, which, in well-balanced minds, reciprocally strengthen each other; unlike the unkind passions, which are constantly engaged in the most angry conflicts of civil war. In this state we desire to experience these *beneficent volitions*, to cultivate a disposition towards them, and to do every correspondent voluntary act. They are for their own sake the objects of desire. They thus constitute a large portion of those emotions, desires, and affections, which regard certain dispositions of the mind and determinations of the will as their sole and ultimate end. These are what are called the moral sense, the moral sentiments, or best though most simply, by the ancient name of *Conscience;* which has the merit, in our language, of being applied to no other purpose, which peculiarly marks the strong working of these feelings on conduct, and which, from its solemn and sacred character, is well adapted to denote the venerable authority of the highest principle of human nature.

Nor is this all: It has already been seen that not only sympathy with the sufferer, but indignation against the wrong-doer, contributes a large and important share towards the moral feelings. We are angry at those who disappoint our wish for the happiness of others. We make the resentment of the innocent person wronged our own. Our moderate anger approves all well-proportioned punishment of the wrong-doer. We hence approve those dispositions and actions of voluntary agents which promote such suitable punishment, and disapprove those which hinder its infliction or destroy its effect; at the head of which may be placed that excess of punishment beyond the average feelings of good men which turns the indignation of the calm bystander against the culprit into pity. In this state, when anger is duly moderated,—when it is proportioned to the wrong,—when it is detached from personal considerations,—when *dispositions and actions are its ultimate objects*,—it becomes a sense of justice, and is so purified as to be fitted to be a new element of conscience. There is no part of morality which is so *directly* aided by a conviction of the necessity of its observance to the general interest, as justice. The connection between them is discoverable by the most common understanding. All public deliberations profess the public welfare to be their object; all laws propose it as their end. This calm principle of public utility serves to mediate between the sometimes repugnant feelings which arise in the punishment of criminals, by repressing undue pity on one hand, and reducing resentment to its proper level on the other. Hence the unspeakable importance of criminal laws as a part of the moral education of mankind. Whenever they carefully conform to the moral sentiments of the age and country,—when they are withheld from approaching the limits within which the disapprobation of good men would confine punishment, they contribute in the highest degree to increase the ignominy of crimes, to make men recoil from the first suggestions of criminality, and to nourish and mature the sense of justice, which lends new vigour to the conscience with which it has been united.

Other contributary streams present themselves. Qualities which are necessary to virtue, but may be subservient to vice, may, independently of that excellence or of that defect, be in themselves admirable. Courage, energy, decision, are of this nature. In their wild state they are often savage and destructive. When they are tamed by the society of the affections, and trained up in obedience to the moral faculty, they become virtues of the highest order, and, by their name of *magnanimity*, proclaim the general sense of mankind that they are the characteristic qualities of a great soul. They retain whatever was admirable in their unreclaimed state, together with all that they borrow from their new associate and their high ruler. Their nature, it must be owned, is prone to evil; but this propensity does not hinder them from being rendered capable of being ministers of good, in a state where the gentler virtues require to be vigorously guarded against the attacks of daring depravity. It is thus that the strength of the well-educated elephant is sometimes employed in vanquishing the fierceness of the tiger, and sometimes used as a means of defence against the shock of his brethren of the same species. The delightful contemplation, however, of these qualities, when purely applied, becomes one of the sentiments of which the dispositions and actions of voluntary agents are the direct and final object. By this resemblance they are associated with the other moral principles, and with them contribute to form Conscience, which, as the master faculty of the soul, levies such large contributions on every province of human nature.

It is important, in this point of view, to consider also the moral approbation which is undoubtedly bestowed *on those dispositions and actions of voluntary agents* which terminate in their own satisfaction, security, and wellbeing. They have been called duties to ourselves, as absurdly as a regard to our own greatest happiness is called self-love. But it cannot be reasonably doubted, that intemperance, improvidence, timidity, even when considered only in relation to the individual, are not only regretted as imprudent, but blamed as morally wrong. It was excellently observed by Aristotle, that a man is not commended as *temperate*, so long as it costs him efforts of *self-denial* to persevere in the practice of temperance, but only when *he prefers that virtue for its own sake.* He is not meek, nor brave, as long as the most vigorous self-command is necessary to bridle his anger or his fear. On the same principle, he may be judicious or prudent; but he is not benevolent if he confers benefits with a view to his own greatest happiness. In like manner, it is ascertained by experience, that all the masters of science and of art—that all those who have successfully pursued truth and knowledge—love them for their own sake, without regard to the generally imaginary dower of interest, or even to the dazzling crown which fame may place on their heads.[1] But it may still be reasonably asked, why these useful qualities are morally improved, and how they become capable of being combined with those public and disinterested sentiments which principally constitute conscience? The answer is, because they are entirely conversant with volitions and voluntary actions, and in that respect resemble the other constituents of conscience, with which they are thereby fitted to mingle and coalesce. Like those other principles, they may be detached from what is personal and outward, and fixed on the dispositions and actions, which are the only means of promoting their ends. The sequence of these principles and acts of will becomes so frequent, that the association between both may be as firm as in the former cases. All those sentiments of which the final object is a state of the will, become thus intimately and inseparably blended; and of that perfect state of solution (if such words may be allowed) the result is *Conscience*—the judge and arbiter of human conduct; which, though it does not supersede *ordinary motives* of virtuous feelings and habits, which are the ordinary motives of good actions, yet exercises a lawful authority even over them, and ought to blend with them. Whatsoever actions and dispositions are approved by conscience acquire the name of virtues or duties: they are pronounced to deserve commendation; and we are justly considered as under a moral *obligation* to practise the actions and cultivate the dispositions.

The coalition of the private and public feelings is very remarkable in two points of view, from which it seems hitherto to have been scarcely observed. *First,* It illustrates very forcibly all that has been here offered to prove, that the peculiar character of the moral sentiments consists in their *exclusive reference to states of will,* and that every feeling which has that quality, when it is purified from all admixture with different objects, becomes capable of being absorbed into Conscience, and of being assimilated to it, so as to become a part of it. For no feelings can be more unlike each other in their object than the private and the social; and yet, as both employ voluntary actions as their sole immediate means, both may be transferred by association to states of the will, in which case they are transmuted into moral sentiments. No example of the coalition of feelings in their general nature less widely asunder, could afford so much support to this position. *Secondly,* By raising qualities useful to ourselves to the rank of virtues, it throws a strong light on the relation of virtue to individual interest; very much as justice illustrates the relation of morality to general interest. The coincidence of morality with individual interest is an important truth in Ethics. It is most manifest in that part of Ethics which we are now considering. A calm regard to our general interest is indeed a faint and infrequent motive of action. Its chief advantage is, that it is regular, and that its movements may be calculated. In deliberate conduct it may often be relied on, though perhaps never safely without knowledge of the whole temper and character. But in moral reasoning at least, the coincidence is of unspeakable advantage. If there be a miserable man who has cold affections, a weak sense of justice, dim perceptions of right and wrong, and faint feelings of them;—if, still more wretched, his heart be constantly torn and devoured by malevolent passions—the vultures of the soul;—we have one resource still left, even in cases so dreadful. Even *he* still retains a human principle, to which we can speak. He must own that he has some wish for his own lasting welfare. We can prove to him that his state of mind is inconsistent with it. It may be impossible indeed to show, that while his disposition continues the same, he can derive any enjoyment from the practice of virtue. But it may be most clearly shown, that every advance in the amendment of that disposition is a step towards even temporal happiness. If he do not amend his character, we may compel him to own that he is at variance with himself, and offends against a principle of which even *he* must recognise the reasonableness.

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[1] See the *Pursuit of Knowledge under Difficulties*, a discourse forming the first part of the third volume of the *Library of Entertaining Knowledge*, London, 1829. The author of this Essay, for it can be no other than Mr Brougham, will by others be placed at the head of those who, in the midst of arduous employments, and surrounded by all the allurements of society, yet find leisure for exerting the unwearied vigour of their minds in every mode of rendering permanent service to the human species; more especially in spreading a love of knowledge, and diffusing useful truth among all classes of men. These voluntary occupations deserve our attention still less as examples of prodigious power than as proofs of an intimate conviction, which binds them by unity of purpose with his public duties, that (to use the almost dying words of an excellent person) "man can neither be happy without virtue, nor actively virtuous without liberty, nor securely free without rational knowledge." (Close of Sir W. Jones's last *Discourse to the Asiatic Society of Calcutta.*)

The formation of Conscience from so many elements, and especially the combination of elements so unlike as the private desires and the social affections, early contributes to give it the appearance of that simplicity and independence which in its mature state really distinguish it. It becomes, from these circumstances, more difficult to distinguish its separate principles; and it is impossible to exhibit them in separate action. The affinity of these various passions to each other, which consists in their having no object but *states of the will,* is the only common property which strikes the mind. Hence the facility with which the general terms, first probably limited to the relations between ourselves and others, are gradually extended to all voluntary acts and dispositions. Prudence and temperance become the objects of moral approbation. When imprudence is immediately disapproved by the by-stander, without deliberate consideration of its consequences, it is not only displeasing, as being pernicious, but it is blamed as *wrong,* though with a censure so much inferior to that bestowed on inhumanity and injustice, as may justify those writers who use the milder term *improper.* At length, when the general words come to signify the objects of moral approbation, and the reverse, they denote merely the power to excite feelings which are as independent as if they were underived, and which coalesce the more perfectly, because they are detached from objects so various and unlike as to render their return to their primitive state very difficult.

The question,[1] why we do not morally approve the useful qualities of actions which are altogether *involuntary,* may now be shortly and satisfactorily answered: because conscience is in perpetual contact, as it were, with all the dispositions and actions of *voluntary* agents, and is by that means indissolubly associated with them exclusively. It has a direct action on the will, and a constant mental contiguity to it. It has no such mental contiguity to involuntary changes. It has never perhaps been observed, that an operation of the conscience precedes all acts deliberate enough to be in the highest sense voluntary, and does so as much when it is defeated as when it prevails. In either case the association is repeated. It extends to the whole of the active man. All passions have a definite outward object to which they tend, and a limited sphere within which they act. But conscience has no object but a state of will; and as an act of will is the sole means of gratifying any passion, conscience is co-extensive with the whole man, and without encroachment curbs or aids every feeling, even within the peculiar province of that feeling itself. As will is the universal means, conscience, which regards will, must be a universal principle. As nothing is interposed between conscience and the will when the mind is in its healthy state, the dictate of conscience is followed by the determination of the will, with a promptitude and exactness which very naturally is likened to the obedience of an inferior to the lawful commands of those whom he deems to be rightfully placed over him. It therefore seems clear, that on the theory which has been attempted, moral approbation must be limited to voluntary operations, and conscience must be universal, independent, and commanding.

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[1] See *supra*, p. 363.

One remaining difficulty may perhaps be objected to the general doctrines of this Dissertation, though it does not appear at any time to have been urged against other modifications of the same principle. "If moral approbation," it may be said, "involve no perception of beneficial tendency, whence arises the coincidence between that principle and the moral sentiments?" It may seem at first sight, that such a theory rests the foundation of morals upon a coincidence altogether mysterious, and apparently capricious and fantastic. Waiving all other answers, let us at once proceed to that which seems conclusive. It is true that conscience rarely contemplates so distant an object as the welfare of all sentient beings. But to what point is every one of its elements directed? What, for instance, is the aim of all the social affections? Nothing but the production of larger or smaller masses of happiness among those of our fellow-creatures who are the objects of these affections. In every case these affections promote happiness, as far as their foresight and their power extend. What can be more conducive, or even necessary, to the being and *wellbeing* of society, than the rules of justice? Are not the angry passions themselves, as far as they are ministers of morality, employed in removing hinderances to the *welfare* of ourselves and others, which is indirectly promoting it? The private passions terminate indeed in the happiness of the individual, which, however, is a part of general happiness, and the part over which we have most power. Every principle of which conscience is composed has some portion of happiness for its object. To that point they all converge. General happiness is not indeed one of the natural objects of conscience, because our voluntary acts are not felt and perceived to affect it. But how small a step is left for reason. It only casts up the items of the account. It has only to discover that the acts of those who labour to promote separate portions of happiness must increase the amount of the whole. It may be truly said, that if observation and experience did not clearly ascertain that beneficial tendency is the constant attendant and mark of all virtuous dispositions and actions, the same great truth would be revealed to us by the voice of conscience. The coincidence, instead of being arbitrary, arises necessarily from the laws of human nature, and the circumstances in which mankind are placed. We perform and approve virtuous actions, partly because conscience regards them as right, partly because we are prompted to them by good affections. All these affections contribute towards general wellbeing, though it were not necessary, nor would it be fit, that the agent should be distracted by the contemplation of that vast and remote object.

The various relations of conscience to religion we have already been led to consider on the principles of Butler, of Berkeley, of Paley, and especially of Hartley, who was led by his own piety to contemplate as the last and highest stage of virtue and happiness, a sort of self-annihilation, which, however unsuitable to the present condition of mankind, yet places in the strongest light the disinterested character of the system, of which it is a conceivable though perhaps not attainable result. The completeness and rigour acquired by conscience, when all its dictates are revered as the commands of a perfectly wise and good Being, are so obvious, that they cannot be questioned by any reasonable man, however extensive his incredulity may be. It is thus that conscience can add the warmth of an affection to the inflexibility of principle and habit. It is true that, in examining the evidence of the divine original of a religious system, in estimating an imperfect religion, or in comparing the demerits of religions of human origin, conscience must be the standard chiefly applied. But it follows with equal clearness, that those who have the happiness to find satisfaction and repose in divine revelation, are bound to consider all those precepts for the government of the will, delivered by it, which are manifestly universal, as the rules to which all their feelings and actions should conform. The true distinction between conscience and a taste for moral beauty has already been pointed out;[1] a distinction which, notwithstanding its simplicity, has been unobserved by philosophers, perhaps on account of the frequent co-operation and intermixture of the two feelings. Most speculators have either denied the existence of the taste, or kept it out of view in their theory, or exalted it to the place which is rightfully filled only by conscience. Yet it is perfectly obvious that, like all the other feelings called pleasures of imagination, it terminates in delightful contemplation, while the moral faculty always aims exclusively at voluntary action. Nothing can more clearly show that this last quality is the characteristic of conscience, than its being thus found to distinguish that faculty from the sentiments which most nearly resemble it, most frequently attend it, and are most easily blended with it.

Some attempt has now been made to develope the fundamental principles of ethical theory, in that historical order in which meditation and discussion brought them successively into a clearer light. That attempt, as far as it regards Great Britain, is at least chronologically complete. The spirit of bold speculation, conspicuous among the English of the seventeenth century, languished after the earlier part of the eighteenth, and seems, from the time of Hutcheson, to have passed into Scotland, where it produced Hume, the greatest of sceptics, and Smith, the most eloquent of modern moralists; besides giving rise to that sober, modest, perhaps timid Philosophy, which is commonly called Scotch,—which has the singular merit of having first strongly and largely inculcated the absolute necessity of admitting certain principles as the foundation of all reasoning, and as being the indispensable conditions of thought itself. In the eye of the moralist, all the philosophers of Scotland, Hume and Smith as much as Reid, Campbell, and Stewart, have also the merit of having avoided the selfish system; and of having, under whatever variety of representation, alike maintained the disinterested nature of the social affections and the supreme authority of the moral sentiments. Brown reared the standard of revolt against the masters of the Scottish School, and in reality, still more than in words, adopted those very doctrines against which his predecessors, after their war against scepticism, uniformly combated. The law of association, though expressed in other language, became the nearly universal principle of his system; and perhaps it would have been absolutely universal if he had not been restrained rather by respectful feelings than by cogent reasons. With him the love of speculative philosophy, as a pursuit, appears to have expired in Scotland. There are some symptoms, yet however very faint, of the revival of a taste for it among the English youth. It was received with approbation in France from M. Royer Collard, the scholar of Stewart more than of Reid, and with enthusiasm from his pupil and successor M. Cousin, who has clothed the doctrines of the Schools of Germany in an unwonted eloquence, which always adorns, but sometimes disguises them.

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[1] See *supra*, p. 384, 385.

The history of Political Philosophy, even if its extent and subdivisions were better defined, would, it is manifest, have occupied another Dissertation, at least equal in length to the present. The most valuable parts of it belong to Civil History. It is too often tainted by a turbulent and factious spirit to be easily combined with the calmer history of the progress of science, or even of the revolutions of speculation. In no age of the world were its principles so interwoven with political events, and so deeply imbued with the passions and divisions excited by them, as in the eighteenth century.

It was at one time the purpose, or rather perhaps hope, of the writer, to close this discourse by an account of the ethical systems which have prevailed in Germany during the last half century; which, maintaining the same spirit amidst great changes of technical language, and even of speculative principle, have now exclusive possession of Europe to the north of the Rhine, have been welcomed by the French youth with open arms, have roused in some measure the languishing genius of Italy, but are still little known and unjustly estimated by the mere English reader. He found himself, however, soon reduced to the necessity of either being superficial, and by consequence uninstructive; or of devoting to that subject a far longer time than he can now spare, and a much larger space than the limits of this work would probably allow. The majority of readers will indeed be more disposed to require an excuse for the extent of what has been done, than for the relinquishment of projected additions. All readers must agree that this is peculiarly a subject on which it is better to be silent than to say too little.

A very few observations, however, on the German Philosophy, as far as relates to its ethical bearings and influence, may perhaps be pardoned. These remarks are not so much intended to be applied to the moral doctrines of that school, considered in themselves, as to those apparent defects in the prevailing systems of Ethics throughout Europe, which seem to have suggested the necessity of their adoption. Kant has himself acknowledged that his whole theory of the percipient and intellectual faculty was intended to protect the first principles of human knowledge against the assaults of Hume. In like manner, his ethical system is evidently framed for the purpose of guarding certain principles, either directly governing, or powerfully affecting practice, which seemed to him to have been placed on unsafe foundations by their advocates, and which were involved in perplexity and confusion, especially by those who adapted the results of various and sometimes contradictory systems to the taste of multitudes, more eager to know than prepared to be taught. To the theoretical reason he superadded the practical reason, which had peculiar laws and principles of its own, from which all the rules of morals may be deduced. The practical reason cannot be conceived without these laws; therefore they are *inherent*. It perceives them to be *necessary* and *universal*. Hence, by a process not altogether dissimilar, at least in its gross results, to that which was employed for the like purpose by Cudworth and Clarke, by Price, and in some degree by Stewart, he raises the social affections, and still more the moral sentiments, above the sphere of enjoyment, and beyond that series of enjoyments which is called happiness. The performance of duty, not the pursuit of happiness, is in this system the chief end of man. By the same intuition we discover that virtue deserves happiness; and as this desert is not uniformly so requited in the present state of existence, it compels us to believe a moral government of the world, and a future state of existence, in which all the conditions of the practical reason will be realized;—truths, of which, in the opinion of Kant, the argumentative proofs were at least very defective, but of which the revelations of the practical reason afforded a more conclusive demonstration than any process of reasoning could supply. The understanding, he owned, saw nothing in the connection of motive with *volition* different from what it discovered in every other uniform sequence of a cause and an effect. But as the moral law delivered by the practical reason issues peremptory and inflexible commands, the power of always obeying them is implied in their very nature. All individual objects, all outward things, must indeed be viewed in the relation of cause and effect. They are necessary conditions of all reasoning. But the acts of the faculty which *wills*, of which we are immediately conscious, belong to another province of mind, and are not subject to these laws of the theoretical reason. The mere intellect must still regard them as necessarily connected; but the practical reason distinguishes its own *liberty* from the *necessity* of nature, conceives volition without at the same time conceiving an antecedent to it, and regards all moral beings as the original authors of their own actions.

Even those who are unacquainted with this complicated and comprehensive system, will at once see the slightness of the above sketch. Those who understand it, will own that so brief an outline could not be otherwise than slight. It will, however, be sufficient for the present purpose, if it render what follows intelligible.

With respect to what is called the practical reason, the Kantian system varies from ours, in treating it as having more resemblance to the intellectual powers than to sentiment and emotion. Enough has already been said on that question. At the next step, however, the difference seems to resolve itself into a misunderstanding. The character and dignity of the human race surely depend, not on the state in which they are born, but on that which they are all destined to attain or to approach. No man would hesitate in assenting to this observation, when applied to the intellectual faculties. Thus, the human infant comes into the world imbecile and ignorant; but a vast majority acquire some vigour of reason and extent of knowledge. Strictly, the human infant is born neither selfish nor social; but the far greater part acquire some provident regard to their own welfare, and a number, probably not much smaller, feel some sparks of affection towards others. On our principles, therefore, as much as on those of Kant, human nature is capable of disinterested sentiments. For we too allow and contend that our moral faculty is a *necessary* part of human nature,—that it *universally* exists in human beings,—that we cannot conceive any moral agents without qualities which are either like, or produce the like effects. It is necessarily regarded by us as co-extensive with human, and even with moral nature. In what other sense can *universality* be predicated of any proposition not identical? Why should it be tacitly assumed that all these great characteristics of conscience should necessarily presuppose its being unformed and underived? What contradiction is there between them and the theory of regular and uniform formation?

In this instance it should seem that a general assent to truth is chiefly if not solely obstructed by an inveterate prejudice, arising from the mode in which the questions relating to the affections and the moral faculty have been discussed among ethical philosophers. Generally speaking, those who contend that these parts of the mind are acquired, have also held that they are, in their perfect state, no more than modifications of self-love. On the other hand, philosophers "of purer fire," who felt that conscience is sovereign, and that affection is disinterested, have too hastily fancied that their ground was untenable, without contending that these qualities were inherent or innate, and absolutely underived from any other properties of mind. If a choice were necessary between these two systems as masses of opinion, without any freedom of discrimination and selection, I should unquestionably embrace that doctrine which places in the clearest light the reality of benevolence and the authority of the moral faculty. But it is surely easy to apply a test which may be applied to our conceptions as effectually as a decisive experiment is applied to material substances. Does not he who, whatever he may think of the origin of these parts of human nature, believes that *actually* conscience is supreme, and affection terminates in its direct object, retain all that for which the partisans of the underived principles value and cling to their system? "But they are made," these philosophers may say, "by this class of our antagonists, to rest on insecure foundations. Unless they are underived, we can see no reason for regarding them as independent." In answer, it may be asked, how is the connection between these two qualities established? It is really assumed. It finds its way easily into the mind under the protection of another coincidence, which is of a totally different nature. The great majority of those speculators who have represented the moral and social feelings as acquired, have also considered them as being mere modifications of self-love, and sometimes as being casually formed and easily eradicated, like local and temporary prejudices. But when the nature of our feelings is thoroughly explored, is it not evident that this coincidence is the result of superficial confusion? The better moralists observed accurately, and reasoned justly, on the province of the moral sense and the feelings in the formed and mature man. They reasoned mistakenly on the origin of these principles. But the Epicureans were by no means right, even on the latter question; and they were totally wrong on the other and far more momentous part of the subject. Their error is more extensive, and infinitely more injurious. But what should now hinder an inquirer after truth from embracing but amending their doctrine where it is partially true, and adopting without any change the just description of the most important principles of human nature which we owe to their more enlightened as well as more generous antagonists?

Though unwilling to abandon the arguments by which, from the earliest times, the existence of the supreme and eternal mind has been established, we, as well as the German philosophers, are entitled to call in the help of our moral nature to lighten the burden of those tremendous difficulties which cloud his moral government. The moral nature is an actual part of man, as much on our scheme as on theirs.

Even the celebrated question of Liberty and Necessity may perhaps be rendered somewhat less perplexing, if we firmly bear in mind that peculiar relation of conscience to will which we have attempted to illustrate. It is impossible for reason to consider occurrences otherwise than as bound together by the connection of cause and effect; and in this circumstance consists the strength of the necessitarian system. But conscience, which is equally a constituent part of the mind, has other laws. It is composed of *emotions and desires, which contemplate only those dispositions which depend on the will.* Now, it is the nature of an emotion to withdraw the mind from the contemplation of every idea but that of the object which excites it. Every desire exclusively looks at the object which it seeks. Every attempt to enlarge the mental vision alters the state of mind, weakens the emotion or dissipates the desire, and tends to extinguish both. If a man, while he was pleased with the smell of a rose, were to reflect on the chemical combinations from which it arose, the condition of his mind would be changed from an enjoyment of the senses to an exertion of the understanding. If, in the view of a beautiful scene, a man were suddenly to turn his thoughts to the disposition of water, vegetables, and earths, on which its appearance depended, he might enlarge his knowledge of geology, but he must lose the pleasure of the prospect. The anatomy and analysis of the flesh and blood of a beautiful woman necessarily suspend admiration and affection. Many analogies here present themselves. When life is in danger either in a storm or a battle, it is certain that less fear is felt by the commander or the pilot, and even by the private soldier actively engaged, or the common seaman laboriously occupied, than by those who are exposed to the peril, but not employed in the means of guarding against it. The reason is not that the one class believe the danger to be less. They are likely in many instances to perceive it more clearly. But having acquired a habit of instantly turning their thoughts to the means of counteracting the danger, their minds are thrown into a state which excludes the ascendency of fear. Mental fortitude entirely depends on this habit. The timid horseman is haunted by the horrors of a fall. The bold and skilful thinks only about the best way of curbing or supporting his horse. Even when all means are equally unavailable, and his condition appears desperate to the by-stander, he still owes to his fortunate habit that he does not suffer the agony of the coward. Many cases have been known where fortitude has reached such strength that the faculties, instead of being confounded by danger, are never raised to their highest activity by a less violent stimulant. The distinction between such men and the coward does not depend on difference of opinion about the reality or extent of the danger, but on a state of mind which renders it more or less accessible to fear. Though it must be owned that the moral sentiments are very different from any other human faculty, yet the above observations seem to be in a great measure applicable to every state of mind. The emotions and desires which compose conscience, while they occupy the mind, must exclude all contemplation of the cause in which the object of these feelings may have originated. To their eye the *voluntary dispositions and actions*, their sole object, must appear to be the first link of a chain. In the view of conscience they have no foreign original. The conscience being so constantly associated with *all volitions*, its view becomes habitual:—being always possessed of some, and capable of intense warmth, it predominates over the habits of thinking of those few who are employed in the analyses of mental occupations. The reader who has in any degree been inclined to adopt the explanations attempted above, of the imperative character of conscience, may be disposed also to believe that they afford some foundation for that conviction of the existence of a power to obey its commands, which (it ought to be granted to the German philosophers) is irresistibly suggested by the commanding tone of all its dictates. If such an explanation should be thought worthy of consideration, it must be very carefully distinguished from that illusive sense by which some writers have laboured to reconcile the feeling of liberty with the reality of necessity.[1] In this case there is no illusion;—nothing is required but the admission, that every faculty observes its own laws, and that when the action of the one fills the mind, that of every other is suspended. The ear cannot see, nor can the eye hear. Why then should not the greater powers of reason and conscience have different habitual modes of contemplating voluntary actions? How strongly do experience and analogy seem to require the arrangement of motive and volition under the class of causes and effects! With what irresistible power, on the other hand, do all our moral sentiments remove extrinsic agency from view, and concentrate all feeling in the agent himself! The one manner of thinking may predominate among the speculative few in their short moments of abstraction; the other will be that of all other men, and of the speculator himself when he is called upon to act, or when his feelings are powerfully excited by the amiable or odious dispositions of his fellow-men. In these workings of various faculties there is nothing that can be accurately described as contrariety of opinion. An intellectual state, and a feeling, never can be contrary to each other. They are too utterly incapable of comparison to be the subject of contrast. They are agents of a perfectly different nature, acting in different spheres. A feeling can no more be called true or false, than a demonstration, considered simply in itself, can be said to be agreeable or disagreeable. It is true, indeed, that in consequence of the association of all mental acts with each other, emotions and desires may occasion habitual errors of judgment;—but liability to error belongs to every exercise of human reason; it arises from a multitude of causes; it constitutes, therefore, no difficulty peculiar to the case before us. Neither truth nor falsehood can be predicated of the perceptions of the senses, but they lead to false opinions. An object seen through different mediums may by the inexperienced be thought to be no longer the same. All men long concluded falsely, from what they saw, that the earth was stationary, and the sun in perpetual motion around it. The greater part of mankind still adopt the same error. Newton and Laplace used the same language with the ignorant, and conformed (if we may not say to their opinion) at least to their habits of thinking on all ordinary occasions, and during the far greater part of their lives. Nor is this all: The language which represents various states of mind is very vague. The word which denotes a compound state is often taken from its *principal* fact, from that which is most *conspicuous*, most easily *called to mind*, most *warmly felt*, or most *frequently recurring*. It is sometimes borrowed from a separate, but, as it were, neighbouring condition of mind. The grand distinction between thought and feeling is so little observed, that we are peculiarly liable to confusion on this subject. Perhaps when we use language which indicates an opinion concerning the acts of the will, we may mean little more than to express strongly and warmly the moral sentiments which voluntary acts alone call up. It would argue disrespect for the human understanding, vainly employed for so many centuries in reconciling contradictory opinions, to propose such suggestions without peculiar diffidence; but before they are altogether rejected, it may be well to consider, whether the constant success of the advocates of necessity on one ground, and of the partisans of free-will on another, does not seem to indicate that the two parties contemplate the subject from different points of view, that neither habitually sees more than one side of it, and that they look at it through the medium of different states of mind.

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[1] Lord Kames, in his *Essays on Morality and Natural Religion*, and in his *Sketches of the History of Man.*

It should be remembered that these hints of a possible reconciliation between seemingly repugnant opinions are proposed, not as perfect analogies, but to lead men's minds into the inquiry, whether that which certainly befalls the mind, in many cases on a small scale, may not, under circumstances favourable to its development, occur with greater magnitude, and more important consequences. The coward and brave, as has been stated, act differently at the approach of danger, because it produces exertion in the one and fear in the other. But very brave men must, by the terms, be few. They have little aid in their highest acts, therefore, from fellow-feeling. They are often too obscure for the hope of praise, and they have seldom been trained to cultivate courage as a virtue. The very reverse occurs in *the different view taken by understanding and by conscience, of the nature of voluntary actions.* The conscientious view must, in some degree, present itself to all mankind. It is therefore unspeakably strengthened by general sympathy. All men respect themselves for being habitually guided by it. It is the object of general commendation; and moral discipline has no other aim but its cultivation. Whoever does not feel more pain from his crimes than from his misfortunes, is looked on with general aversion. And when it is considered that a Being of perfect wisdom and goodness estimates us according to the degree in which conscience governs our voluntary acts, it is surely no wonder that, in this most important discrepancy between the great faculties of our nature, we should consider the best habitual disposition to be that which the coldest reason shows us to be most conducive to welldoing and wellbeing.

On every other point, at least, it should seem that, without the multiplied suppositions and immense apparatus of the German School, the authority of morality may be vindicated, the disinterestedness of human nature asserted, the first principles of knowledge secured, and the hopes and consolations of mankind preserved. Ages may yet be necessary to give to ethical theory all the forms and language of science, and to apply it to the multiplied and complicated facts and rules which are within its province. In the mean time, if any statement of the opinions here unfolded or intimated shall be proved to be at variance with the reality of social affections, and with the feeling of moral distinction, the author of this Dissertation will be the first to relinquish a theory which will then show itself inadequate to explain the most indisputable, as well as by far the most important, parts of human nature. If it shall be shown to lower the character of man, to cloud his hopes, or to impair the sense of duty, he will be grateful to those who may point out his error, and deliver him from the poignant regret of adopting opinions which lead to consequences so pernicious.

NOTES AND ILLUSTRATIONS.

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Note A, p. 321.

The remarks of Cicero on the Stoicism of Cato are perhaps the most perfect specimen of that refined raillery which attains the object of the orator without general injustice to the person whose authority is for the moment to be abated.

"Accessit his doctrina non moderata, nec mitis, sed, ut mihi videtur, paulo asperior et durior quam aut veritas aut natura patiatur." After an enumeration of the Stoical paradoxes, he adds: "Hæc homo ingeniosissimus M. Cato arripuit, neque disputandi causa, ut magna pars, sed ita vivendi. Nostri autem illi (fatebor enim me quoque in adolescentia diffisum ingenio meo quæsisse adjumenta doctrinæ) nostri, inquam, illi a Platone atque Aristotele moderati homines et temperati aiunt apud sapientem valere aliquando gratiam; viri boni esse misereri;........omnes virtutes mediocritate quadam moderatas. Hos ad magistros si qua te fortuna, Cato, cum ista natura detulisset, non tu quidem vir melior esses, nec fortior, nec temperantior, nec justior (neque enim esse posses), sed paulo ad lenitatem propensior." (Cicero *pro Murena.*)

Note B, p. 325.

The greater part of the following extract from Grotius's *History of the Netherlands* is inserted as the best abridgement of the ancient history of these still subsisting controversies known in our time. I extract also the introduction as a model of the manner in which an historian may state a religious dispute which has influenced political affairs; but far more because it is an unparalleled example of equity and forbearance in the narrative of a contest of which the historian was himself a victim.

"Habuit hic annus (1608) haud spernendi quoque mali semina, vix ut arma desierant, exorto publicæ religionis dissidio, latentibus initiis, sed ut paulatim in majus erumperet. Lugduni sacras literas docebant viri eruditione præstantes Gomarus et Arminius, quorum ille æterna Dei lege fixum memorabat, cui hominum salus destinaretur, quis in exitium tenderet; inde alios ad pietatem trahi, et tractos custodiri ne elabantur; relinqui alios communi humanitatis vitio et suis criminibus involutos: hic vero contra integrum judicem, sed eundem optimum patrem, id reorum fecisse discrimen, ut peccandi pertæsis fiduciamque in Christum reponentibus veniam ac vitam daret, contumacibus pœnam; Deoque gratum, ut omnes resipiscant, ac meliora edocti retineant; sed cogi neminem. Accusabantque invicem; Arminius Gomarum, quod peccandi causas Deo ascriberet, ac fati persuasione teneret immobiles animos; Gomarus Arminium, quod longius ipsis Romanensium scitis hominem arrogantia impleret, *nec pateretur soli Deo acceptam ferri, rem maximam, bonam mentem.* Constat his queis cura legere veterum libros, antiquos Christianorum tribuisse hominum voluntati vim liberam, tam in acceptanda, quam in retinenda disciplina; unde sua præmiis ac suppliciis æquitas. Neque iidem tamen omisere cuncta divinam ad bonitatem referre, cujus munere salutare semen ad nos pervenisset, ac cujus singulari auxilio pericula nostra indigerent. Primus omnium Augustinus, ex quo ipsi cum Pelagio et eum secutis certamen (*nam ante aliter et ipse senserat*), acer disputandi, ita libertatis vocem relinquere, ut ei decreta quædam Dei præponeret, quæ vim ipsam destruere viderentur. At per Græciam quidem Asiamque retenta vetus illa ac simplicior sententia. Per occidentem magnum Augustini nomen multos traxit in consensum, repertis tamen per Galliam et alibi qui se opponerent. Posterioribus sæculis, cum schola non alio magis quam Augustino doctore uteretur, quis ipsi sensus, quis dexter pugnare visa conciliandi modus, diu inter Francisci et Dominici familiam disputato, doctissimi Jesuitarum, cum exactiori subtilitate nodum solvere laborassent, Romæ accusati ægre damnationem effugere. At Protestantium princeps, Lutherus, egressus monasterio quod Augustini ut nomen, ita sensus sequebatur, parte Augustini arrepta, id quod is reliquerat, libertatis nomen, cœpit exscindere; quod tam grave Erasmo visum, ut cum cætera ipsius aut probaret aut silentio transmitteret, hic objiciat sese: cujus argumentis motus Philippus Melanchthon, Lutheri adjutor, quæ prius scripserat immutavit, auctorque fuit Luthero, quod multi volunt, certe quod constat Lutheranis, deserendi decreta rigida et conditionem respuentia; sic tamen ut libertatis vocabulum quam rem magis perhorrescerent. At in altera Protestantium parte dux Calvinus, primis Lutheri dictis in hac controversia inhærescens, novis ea fulsit præsidiis, *addiditque intactum Augustino, veram ac salutarem fidem rem esse perpetuam et amitti nesciam:* cujus proinde qui sibi essent conscii, eos æternæ felicitatis jam nunc certos esse, quos interim in crimina, quantumvis gravia, prolabi posse non diffitebatur. Auxit sententiæ rigorem Genevæ Beza, per Germaniam Zanchius, Ursinus, Piscator, sæpe eo usque provecti, ut, quod alii anxie vitaverant, apertius nonnunquam traderent, etiam peccandi necessitatem a prima causa pendere: quæ ampla Lutheranis criminandi materia." (H. Grotii *Hist.* lib. xvii. p. 552.)

Note C, p. 325.

The Calvinism, or rather Augustinianism, of Aquinas, is placed beyond all doubt by the following passages:—"Prædestinatio est causa gratiæ et gloriæ." (*Opera*, VII. 356, edit. Paris. 1664.)

"Numerus prædestinatorum certus est." (*Ibid.* 363.)

"Præscientia meritorum nullo modo est causa prædestinationis divinæ." (*Ibid.* 370.)

"Liberum arbitrium est facultas qua bonum eligitur, gratia assistente, vel malum, eadem desistente." (*Ibid.* VIII. 222.)

"Deus inclinat ad bonum administrando virtutem agendi et monendo ad bonum. Sed ad malum dicitur inclinare in quantum gratiam non præbet, per quam aliquis a malo retraheretur." (*Ibid.* 364.)

On the other side:

"Accipitur fides pro eo quo creditur, et est virtus, et pro eo quod creditur, et non est virtus. Fides qua creditur, si cum caritate sit, virtus est." (*Ibid.* IX. 236.)

"Divina bonitas est primum principium communicationis totius quam Deus creaturis largitur."

"Quamvis omne quod Deus vult justum sit, non tamen ex hoc justum dicitur quod Deus illud vult." (*Ibid.* 697.)

Note D, p. 325.

The Augustinian doctrine is, with some hesitation and reluctance, acquiesced in by Scotus, in that milder form which ascribes election to an express decree, and considers the rest of mankind as only left to the deserved penalties of their transgressions. "In hujus quæstionis solutione mallem alios audire quam docere." (Scoti *Opera*, V. 1329. Lugd. 1639.) This modesty and prudence is foreign from the dogmatical genius of a Schoolman; and these qualities are still more apparent in the very remarkable language which he applies to the tremendous doctrine of reprobation. "Eorum autem non miseretur (scil. Deus) *quibus gratiam non præbendam esse æquitate occultissima et ab humanis sensibus remotissima judicat.*" (*Ibid.* 1329.) In the commentary on Scotus which follows, it appears that his acute disciple Ockham disputed very freely against the opinions of his master. "*Mala fieri bonum est*" is a startling paradox, quoted by Scotus from Augustin. (*Ibid.* 1381.) It appears that Ockham saw no difference between election and reprobation, and considered those who embraced only the former as at variance with themselves. (*Ibid.* 1313.)

Scotus, at great length, contends that our thoughts (consequently our opinions) are not subject to the will. (VI. 1054–1056.) One step more would have led him to acknowledge that all erroneous judgment is involuntary, and therefore inculpable and unpunishable, however pernicious.

His attempt to reconcile foreknowledge with contingency (V. 1300–1327), is a remarkable example of the power of human subtlety to keep up the appearance of a struggle where it is impossible to make one real effort.

But the most dangerous of all the deviations of Scotus from the system of Aquinas is, that he opened the way to the opinion that the distinction of right and wrong depends on the mere will of the Eternal Mind. The absolute power of the Deity, according to him, extends to all but contradictions. His regular power (*ordinata*) is exercised conformably to an order established by himself; "SI PLACET VOLUNTATI, sub qua libera est, RECTA EST LEX." (SCOT. V. 1368, *et seq.*)

NOTE E, p. 325.

Αλλα μην ψυχην γε ισμεν ακουσαν ϖασαν ϖαν αγνοουσαν.
(PLAT. *Soph.* edit. Bip. II. 224.)
Πασαν ακουσιον αμαθιαν ειναι. (*Ibid.* 227.)

Plato is quoted on this subject by Marcus Aurelius, in a manner which shows, if there had been any doubt, the meaning to be, that all *error* is involuntary.

Πασα ψυχη ακουσα, φησιν (Πλατων), στερεται αληθειας.
Every mind is unwillingly led from truth.
(EPICT. lib. i. cap. xxviii.)

Augustin closes the long line of ancient testimony to the involuntary character of error: "Quis est qui velit decipi? Fallere nolunt boni; falli autem nec boni volunt nec mali." (AUG. *Serm. de Verbo.*)

NOTE F, p. 326.

From a long, able, and instructive dissertation by the commentator on Scotus, it appears that this immoral dogma was propounded in terms more bold and startling by Ockham, who openly affirmed, that "moral evil was only evil because it was prohibited." "Ochamus, qui putat quod nihil posset esse malum sine voluntate prohibitiva Dei, hancque voluntatem esse liberam; sic ut posset eam non habere, et consequenter ut posset fieri quod nulla prorsus essent mala." (SCOT. VII. p. 859.) But, says the commentator, "Dico primo legem naturalem non consistere in jussione ulla quæ sit actus voluntatis Dei. Hæc est communissima theologorum sententia." (SCOT. VII. p. 858.) And indeed the reason urged against Ockham completely justifies this approach to unanimity. "For," he asks, "why is it right to obey the will of God? Is it because our moral faculties perceive it to be right? But they equally perceive and feel the authority of all the primary principles of morality; and if this answer be made, it is obvious that those who make it do in effect admit the independence of moral distinctions on the will of God."

"If God," said Ockham, "had commanded his creatures to hate himself, hatred of God would have been praiseworthy." (DOMIN. SOTO *de Justitia et Jure*, lib. ii. quæst. 3, "*Utrum præcepta Decalogi sint dispensabilia;*" a book dedicated to Don Carlos, the son of Philip II.) Suarez, the last scholastic philosopher, rejected the Ockhamical doctrine, but allowed will to be a *part* of the foundation of morality. "Voluntas Dei *non est tota* ratio bonitatis aut malitiæ." (SUAREZ *de Legibus*, lib. ii. 66, p. 71. edit. Lond. 1679.)

As the great majority of the Schoolmen supported their opinion of this subject by the consideration of eternal and immutable ideas of right and wrong in the divine intellect, it was natural that the Nominalists, of whom Ockham was the founder, who rejected all general ideas. should also have rejected those moral distinctions which were then supposed to originate in such ideas. Gerson was a celebrated Nominalist; and he was the more disposed to follow the opinions of his master, because they agreed in maintaining the independence of the State on the Church, and the superiority of the Church over the Pope.

NOTE G, p. 326.

It must be premised that *Charitas* among the ancient divines corresponded with Ερως of the Platonists, and with the Φιλια of later philosophers, as comprehending the love of all that is loveworthy in the Creator or his creatures. It is the theological virtue of charity, and corre-

sponds with no term in use among modern moralists. "Cum objectum amoris sit bonum, dupliciter potest aliquis tendere in bonum alicujus rei; uno modo, quod bonum *illius rei ad alterum referat*, sicut amat quis vinum in quantum dulcedinem vini peroptat; et hic amor vocatur a quibusdam amor concupiscentiæ. *Amor autem iste non terminatur ad rem quæ dicitur amari, sed reflectitur ad rem illam cui optatur bonum illius rei.* Alio modo amor fortior in bonum alicujus rei, *ita quod ad rem ipsam* TERMINATUR; et hic est amor benevolentiæ. Qua bonum nostrum in Deo perfectum est, sicut in causa universali bonorum; ideo bonum *in ipso esse magis naturaliter complacet* quam in nobis *ipsis:* et ideo etiam amore amicitiæ *naturaliter Deus* ab homine plus seipso diligitur."

The above quotations from Aquinas will probably be sufficient for those who are acquainted with these questions, and they will certainly be thought too large by those who are not. In the next question he inquires, whether in the love of God there can be any view to reward. He appears to consider himself as bound by authority to answer in the affirmative; and he employs much ingenuity in reconciling a certain expectation of reward with the disinterested character ascribed by him to piety in common with all the affections which terminate in other beings. "*Nihil aliud est merces nostra quam perfrui Deo.* Ergo charitas non solum non excludit, sed etiam facit habere oculum ad mercedem." In this answer he seems to have anticipated the representations of Jeremy Taylor (*Sermon on Growth in Grace*); of Lord Shaftesbury (*Inquiry concerning Virtue*, book i. part iii. sect. 3); of Mr T. Erskine (*Freeness of the Gospel*, Edinb. 1828); and more especially of Mr John Smith (*Discourses*, Lond. 1660). No extracts could convey a just conception of the observations which follow, unless they were accompanied by a longer examination of the technical language of the Schoolmen than would be warranted on this occasion. It is clear that he distinguishes well the affection of piety from the happy fruits, which, as he cautiously expresses it, "are in the nature of a reward," just as the consideration of the pleasures and advantages of friendship may enter into the affection and strengthen it, though they are not its objects, and never could inspire such a feeling. It seems to me also that he had a dimmer view of another doctrine, by which we are taught, that though our own happiness be not the end which we pursue in loving others, yet it may be the final cause of the insertion of disinterested affections into the nature of man. "Ponere mercedem aliquam finem amoris ex parte amati, est contra rationem amicitiæ. Sed ponere mercedem esse finem amoris ex parte amantis, non tamen ultimum, prout scilicet ipse amor est quædam operatio amantis, non est contra rationem amicitiæ. Possum operationem amoris amare propter aliquid aliud, salva amicitia. Potest habeas *charitatem habere oculum ad mercedem, uti ponat beatitudinem creatam finem amoris, non autem finem amati.*" Upon the last words my interpretation chiefly depends. The immediately preceding sentence must be owned to have been founded on a distinction between viewing the good fruits of our own affections as enhancing their intrinsic pleasures, and feeling love for another on account of the advantage to be derived from him; which last is inconceivable.

NOTE H, p. 326.

"Potestas spiritualis et secularis utraque deducitur a potestate divina; ideo in tantum secularis est sub spirituali, in quantum est a Deo supposita; scilicet, in his quæ ad salutem animæ pertinent. In his autem quæ ad bonum civile spectant, est magis obediendum potestati seculari; sicut illud Matthæi, 'Reddite quæ sunt Cæsaris Cæsari.'" What follows is more doubtful. "Nisi *forte* potestati spirituali etiam potestas secularis conjungatur, ut in Papa, qui utriusque potestatis apicem tenet." (VIII. 435.) Here, says the French editor, it may be doubted whether Aquinas means the Pope's temporal power in his own dominions, or a secular authority indirectly extending over all for the sake of religion. My reasons for adopting the more rational construction are shortly these:—1. The text of Matthew is so plain an assertion of the independence of both powers, that it would be the height of extravagance to quote it as an *authority* for the dependence of the state. At most it could only be represented as *reconcilable* with such a dependence in one case. 2. The word *forte* seems manifestly to refer to the territorial sovereignty acquired by the Popes. If they have a general power in secular affairs, it must be because it is necessary to their spiritual authority; and in that case to call it fortuitous would be to ascribe to it an adjunct destructive of its nature. 3. His former reasoning on the same question seems to be decisive. The power of the Pope over bishops, he says, is not founded merely in his superior nature, but in their authority being altogether derived from his, as the proconsular power from the imperial. Therefore he infers that this case is not analogous to the relation between the civil and spiritual power, which are alike derived from God. 4. Had an Italian monk of the twelfth century really intended to affirm the Pope's temporal authority, he probably would have laid it down in terms more explicit and more acceptable at Rome. Hesitation and ambiguity are here indications of unbelief. Mere veneration for the apostolical see might present a more precise determination against it, as it caused the quotation which follows, respecting the primacy of Peter. (Aquin. *Opera*, VIII. 434, 435.)

A mere abridgement of these very curious passages might excite a suspicion that I had tinctured Aquinas unconsciously with a colour of my own opinions. Extracts are very difficult, from the scholastic method of stating objections and answers, as well as from the mixture of theological authorities with philosophical reasons.

Note I, p. 328.

The debates in the first assembly of the Council of Trent (1546), between the Dominicans who adhered to Aquinas, and the Franciscans who followed Scotus on original sin, justification, and grace, are to be found in Fra Paolo, *Istoria del Concilio Tridentino*, lib. ii. They show how much metaphysical controversy is hid in a theological form, how many disputes of our times are of no very ancient origin, and how strongly the whole western church, through all the divisions into which it has been separated, has manifested the same unwillingness to avow the Augustinian system, and the same fear of contradicting it. To his admirably clear and short statement of these abstruse controversies, must be added that of his accomplished opponent Cardinal Pallavicino (lib. vii. and viii.), who shows still more evidently the strength of the Augustinian party, and the disposition of the Council to tolerate opinions almost Lutheran, if not accompanied by revolt from the Church. A little more compromising disposition in the Reformers might have betrayed reason to a prolonged thraldom. We must esteem Erasmus and Melanchthon, but we should reserve our gratitude for Luther and Calvin. The Scotists maintained their doctrine of merit of congruity, waived by the Council, and soon after condemned by the Church of England; by which they meant that they who had good dispositions always received the divine grace, not indeed as a reward of which they were worthy, but as aid which they were fit and willing to receive. The Franciscans denied that belief was in the power of man. "I Francescani lo negavano seguendo Scoto, qual vuole che siccome dalle dimostrazioni per necessità nasce la scienza, così dalle persuasioni nasca la fede; e ch'essa é nell' intelletto, il quale é agente naturale, e mosso naturalmente dall'oggetto. Allegavano l'esperienza, che nessuno può credere che vuole, ma quello che gli par vero." (Fra Paolo, *Istoria del Concilio Tridentino*, I. 193. edit. Helmstadt, 1763, 4to.)

Cardinal Sforza Pallavicino, a learned and very able Jesuit, was appointed, according to his own account, in 1651, many years after the death of Fra Paolo, to write a true history of the Council of Trent, as a corrective of the misrepresentations of the celebrated Venetian. Algernon Sidney, who knew this court historian at Rome, and who may be believed when he speaks well of a Jesuit and a Cardinal, commends the work in a letter to his father, Lord Leicester. At the end of Pallavicino's work is a list of three hundred and sixty errors in matters of fact, which the Papal party pretend to have detected in the independent historian, whom they charge with heresy or infidelity, and, in either case, with hypocrisy.

Notes and Illustrations.

Note K, p. 330.

"Hoc tempore, Ferdinando et Isabella regnantibus, in academia Salmantina jacta sunt robustioris theologiæ semina; ingentis enim famæ vir Franciscus de Victoria, non tam lucubrationibus editis, quamvis hæc non magnæ molis at magni pretii sint, sed doctissimorum theologorum educatione, quamdiu fuerit sacræ scientiæ honos inter mortales, vehementer laudabitur." (Antonii *Bibl. Hisp. Nova*, Præf. iv. Madrid, 1783.) "Si ad morum instructores respicias, Sotus iterum nominabitur." (*Ibid.*)

Note L, p. 330.

The title of the published account of the conference at Valladolid is, "The controversy between the Bishop of Chiapa and Dr Sepulveda; in which the Doctor contended that the conquest of the Indies from the natives was lawful, and the Bishop maintained that it was unlawful, tyrannical, and unjust, in the presence of many theologians, lawyers, and other learned men assembled by his Majesty." (Antonii *Bibl. Hisp. Nova*, tom. i. p. 192.)

Las Casas died in 1566, in the 92d year of his age; Sepulveda died in 1571, in his 82d year.

Sepulveda was the scholar of Pomponatius, and a friend of Erasmus, Cardinal Pole, Aldus Manutius, &c. In his book *De Justis Belli Causis contra Indos suscepti*, he contended only that the king might justly "ad ditionem Indos, non herilem sed regiam et civilem, lege belli redigere." (Antonius in voce *Sepulveda: Bibl. Hisp. Nova*, tom. i. p. 703.)

But this smooth and specious language covered a poison. Had it entirely prevailed, the cruel consequence of the defeat of the advocate of the oppressed would alone have remained; the limitations and softenings employed by their opponent to obtain success would have been speedily disregarded and forgotten.

Covarruvias, another eminent Jurist, was sent by Philip II. to the Council of Trent, at its renewal in 1560, and, with Cardinal Buoncampagni, drew up the decrees of reformation. Francis Sanchez, the father of philosophical grammar, published his *Minerva* at Salamanca in 1587; so active was the cultivation of philosophy in Spain in the age of Cervantes.

Notes and Illustrations.

Note M, p. 343.

"Alors en repassant dans mon esprit les diverses opinions qui m'avoient tour-à-tour entraîné depuis ma naissance, je vis que bien qu'aucune d'elles ne fût assez évidente pour produire immédiatement la conviction, elles avoient divers degrés de vraisemblance, et que l'assentiment intérieur s'y prêtoit ou s'y refusoit à différentes mesures. Sur cette première observation, comparant entr' elles toutes ces différentes idées dans le silence des préjugés, je trouvai que la première, et la plus commune, étoit aussi la plus simple et la plus raisonnable; et qu'il ne lui manquoit, pour réunir tous les suffrages, que d'avoir été proposée la dernière. Imaginez tous vos philosophes anciens et modernes, ayant d'abord épuisé leur bizarres systêmes de forces, de chances, de fatalité, de nécessité, d'atomes, de monde animé, de matiere vivante, de matérialisme de toute espece; et après eux tous l'illustre Clarke, éclairant le monde, annonçant enfin l'Etre des êtres, et le dispensateur des choses. Avec quelle universelle admiration, avec quel applaudissement unanime n'eût point été reçu ce nouveau systême si grand, si consolant, si sublime, si propre à élever l'âme, à donner une base à la vertu, et en même tems si frappant, si lumineux, si simple, et, ce me semble, offrant moins de choses incompréhensibles à l'esprit humain, qu'il n'en trouve d'absurdes en tout autre systême! Je me disois, les objections insolubles sont communes à tous, parceque l'esprit de l'homme est trop borné pour les résoudre: elles ne prouvent donc rien contre aucun par préférence, mais quelle différence entre les preuves directes."—(*Emile*, tome III. livre iv. p. 25.)

Note N, p. 353.

"Est autem *jus* quædam potentia moralis, et obligatio necessitas moralis. *Moralem* autem intelligo, quæ apud virum bonum æquipollet naturali: Nam ut præclare jurisconsultus Romanus ait, *quæ contra bonos mores sunt, ea nec* *facere nos posse credendum est. Vir bonus* autem est, qui amat omnes, quantum ratio permittit. *Justitiam* igitur, quæ virtus est hujus affectus rectrix, quem Φιλανθρωπιαν Græci vocant, commodissime, ni fallor, definiemus caritatem sapientis, hoc est, sequentem sapientiæ dictata. Itaque, quod *Carneades* dixisse fertur, justitiam esse summam stultitiam, quia alienis utilitatibus consuli jubeat, neglectis propriis, ex ignorata ejus definitione natum est. *Caritas* est benevolentia universalis, et *benevolentia* amandi sive diligendi habitus. *Amare* autem sive diligere est felicitate alterius delectari, vel, quod eodem redit, felicitatem alienam adsciscere in suam. Unde difficilis nodus solvitur, magni etiam in Theologia momenti, quomodo amor non mercenarius detur, qui sit a spe metuque et omni utilitatis respectu separatus: scilicet, quorum utilitas delectat, eorum felicitas nostram ingreditur, nam quæ delectant, per se expetuntur. Et uti pulchrorum contemplatio ipsa jucunda est, pictaque tabula *Raphaelis* intelligentem afficit, etsi nullos census ferat, adeo ut in oculis deliciisque feratur, quodam simulacro amoris; ita quum res pulchra simul etiam felicitatis est capax, transit affectus in verum amorem. Superat autem *divinus amor* alios amores, quos Deus cum maximo successu amare potest, quando Deo simul et felicius nihil est, et nihil pulchrius felicitateque dignius intelligi potest. Et quum idem sit potentiæ sapientiæque summæ, felicitas ejus non tantum ingreditur nostram (si sapimus, id est, ipsum amamus), sed et facit. Quia autem sapientia caritatem dirigere debet, hujus quoque definitione opus erit. Arbitror autem notioni hominum optime satisfieri, si *sapientiam* nihil aliud esse dicamus, quam ipsam scientiam felicitatis." (Leibnitii *Opera*, tom. IV. pars iii. p. 294.)

"Et jus quidem merum sive strictum nascitur ex principio servandæ pacis; æquitas sive caritas ad majus aliquid contendit, ut, dum quisque alteri prodest quantum potest, felicitatem suam augeat in aliena; et, ut verbo dicam, jus strictum miseriam vitat, jus superius ad felicitatem tendit, sed qualis in hanc mortalitatem cadit. Quod vero ipsam vitam, et quicquid hanc vitam expetendam facit, magno commodo alieno posthabere debeamus, ita ut maximos etiam dolores in aliorum gratiam perferre oporteat; magis pulchre præcipitur a philosophis quam solide demonstratur. Nam decus et gloriam, et animi sui virtute gaudentis sensum, ad quæ sub honestatis nomine provocant, cogitationis sive mentis bona esse constat, magna quidem, sed non omnibus nec omni malorum acerbitati prævalitura, quando non omnes æque imaginando afficiuntur; præsertim quos neque educatio liberalis, neque consuetudo vivendi ingenua, vel vitæ sectæve disciplina ad honoris æstimationem, vel animi bona sentienda assuefecit. Ut vero universali demonstratione conficiatur, omne honestum esse utile, et omne turpe damnosum, assumenda est immortalitas animæ, et rector universi Deus. Ita fit, ut omnes in civitate perfectissima vivere intelligamur, sub monarcha, qui nec ob sapientiam falli, nec ob potentiam vitari potest; idemque tam amabilis est, ut felicitas sit tali domino servire. Huic igitur qui animam impendit, Christo docente, eam lucratur. Hujus potentia providentiaque efficitur, ut omne jus in factum transeat, ut nemo lædatur nisi a se ipso, ut nihil recte gestum sine præmio sit, nullum peccatum sine pœna." (*Ibid.* p. 296.)

Note O, p. 356.

The writer of this Discourse was led, on a former occasion, by a generally prevalent notion, too nearly to confound the theological doctrine of predestination with the philosophical opinion which supposed the determination of the will to be, like other events, produced by adequate causes. (See a criticism on Mr Stewart's Dissertation, *Edinb. Review*, XXXVI. 255.) More careful reflection has corrected a confusion common to him with most writers on the subject. What is called *Sublapsarian Calvinism*, which was the doctrine of the most eminent men, including Augustin and Calvin himself, ascribed to God, and to man before the fall, what is called free-will, which they even own still to exist in all the ordinary acts of life, though it be lost with respect to religious morality. The decree of election, on this scheme, arises from God's foreknowledge that man was to fall, and that all men became thereby with justice liable to eternal punishment. The election of some to salvation was an act of divine goodness, and the preterition of the rest was an exercise of holiness and justice.

This sublapsarian predestination is evidently irreconcilable with the doctrine of necessity, which considers free-will, or volitions not caused by motives, as absolutely inconsistent with the definition of an intelligent being, which is, that he acts from a motive, or, in other words, with a purpose.

The supralapsarian scheme, which represents the fall itself as fore-ordained, may indeed be built on necessitarian principles. But on that scheme original sin seems wholly to lose that importance which the former system gives it as a revolution in the state of the world, requiring an interposition of divine power to remedy a part of its fatal effects. It becomes no more than the first link in the chain of predestined offences. Yet both Catholic and Protestant predestinarians have borrowed the arguments and distinctions of philosophical necessitarians. One of the propositions of Jansenius, condemned by the bull of Innocent X. in 1653, is, that "to merit or demerit in a state of lapsed nature, it is not necessary that there should be in man a liberty free from necessity; it is sufficient that there be a liberty free from constraint." (Dupin, *Histoire de l'Eglise en abrégé*, siècle xvii. livre iv. chap. viii. p. 193.) Luther, in his once famous treatise *de Servo Arbitrio* against Erasmus (printed in 1526), expresses himself as follows: "Hic est fidei summus gradus, credere illum esse clementem qui tam paucos salvat, tam multos damnat; credere justum qui sua voluntate nos necessario damnabiles facit, ut videatur, ut Erasmus refert, delectari cruciatibus miserorum, et odio potius quam amore dignus." My copy of this stern and abusive book is not paged. In another passage, he states the distinction between co-action and necessity as familiar a hundred and thirty years before it was proposed by Hobbes, or condemned in the Jansenists. "Necessario dico, non coacte, sed, ut illi dicunt, necessitate immutabilitatis, non coactionis; hoc est, homo, cum vocat Spiritus Dei, non quidem violentia, velut raptus obtorto collo, nolens facit malum, quemadmodum fur aut latro nolens ad pœnam ducitur, sed sponte et libera voluntate facit." He uses also the illustration of Hobbes, from the difference between a stream *forced* out of its course and *freely* flowing in its channel.

Note P, p. 368.

Though some parts of the substance of the following letter have already appeared in various forms, perhaps the account of Mr Hume's illness, in the words of his friend and physician Dr Cullen, will be acceptable to many readers. I owe it to the kindness of Mrs Baillie, who had the goodness to copy it from the original, in the collection of her late learned and excellent husband, Dr Baillie. Some portion of what has been formerly published I do not think it necessary to reprint.

From Dr Cullen to Dr Hunter.

"My Dear Friend,—I was favoured with yours by Mr Halket on Sunday, and have answered some part of it by a gentleman whom I was otherwise obliged to write by; but as I was not certain how soon that might come to your hand, I did not answer your postscript; in doing which, if I can oblige you, a part of the merit must be that of the information being early, and I therefore give it you as soon as I possibly could. You desire an account of Mr Hume's last days, and I give it you with some pleasure; for though I could not look upon him in his illness without much concern, yet the tranquillity and pleasantry which he constantly discovered did even then give me satisfaction, and, now that the curtain is dropped, allows me to indulge the less allayed reflection. He was truly an example *des grands hommes qui sont morts en plaisantant*....For many weeks before his death he was very sensible of his gradual decay; and his answer to inquiries after his health was, several times, that he was going as fast as his enemies could wish, and as easily as his friends could desire. He was not, however, without a frequent recurrence of pain and uneasiness; but he passed most part of the day in his drawing-room, admitted the visits of his friends, and, with his usual spirit, conversed with them upon literature, politics, or whatever else was accidentally started. In conversation he seemed to be perfectly at ease, and to the last abounded with that pleasantry, and those curious and entertaining anecdotes, which ever distinguished him. This, however, I always considered rather as an effort to be agreeable; and he at length acknowledged that it became too much for his strength. For a few days before his death, he became more averse to receive visits; speaking became more and more difficult for him, and for twelve hours before his death his speech failed altogether. His senses and judgment did not fail till the last hour of his life. He constantly discovered a strong sensibility to the attention and care of his friends; and, amidst great uneasiness and languor, never betrayed any peevishness or impatience. This is a general account of his last days; but a particular fact or two may perhaps convey to you a still better idea of them.

* * * * *

‘About a fortnight before his death, he added a codicil to his will, in which he fully discovered his attention to his friends, as well as his own pleasantry. What little wine he himself drank was generally port, a wine for which his friend the poet [John Home] had ever declared the strongest aversion. David bequeaths to his friend John one bottle of port; and, upon condition of his drinking this even at two down-sittings, bestows upon him twelve dozen of his best claret. He pleasantly adds, that this subject of wine was the only one upon which they had ever differed. In the codicil there are several other strokes of raillery and pleasantry, highly expressive of the cheerfulness which he then enjoyed. He even turned his attention to some of the simple amusements with which he had been formerly pleased. In the neighbourhood of his brother's house in Berwickshire is a brook, by which the access in time of floods is frequently interrupted. Mr Hume bequeaths L.100 for building a bridge over this brook, but upon the express condition that none of the stones for that purpose shall be taken from a quarry in the neighbourhood, which forms part of a romantic scene in which, in his earlier days, Mr Hume took particular delight. Otherwise the money to go to the poor of the parish.

“These are a few particulars which may perhaps appear trifling; but to me no particulars seem trifling that relate to so great a man. It is perhaps from trifles that we can best distinguish the tranquillity and cheerfulness of the philosopher, at a time when the most part of mankind are under disquiet, anxiety, and sometimes even horror....I had gone so far when I was called to the country; and I have returned only so long before the post as to say, that I am most affectionately yours,

“William Cullen.

“*Edinburgh*, 17*th September* 1776.”

Note Q, p. 369.

Pyrrho was charged with carrying his scepticism so far as not to avoid a carriage if it was driven against him. Ænesidemus, the most famous of ancient sceptics, with great probability vindicates the more ancient doubter from such lunacy, of which indeed his having lived to the age of ninety seems sufficient to acquit him. Αινεσιδημος δε φησι φιλοσοφειν μεν αυτον κατα τον της εποχης λογον, μη μεντοι γε απροορατως ἑκαστα πραττειν. (Diog. Laert. lib. ix. sect. 62.)

Brief and imperfect as our accounts of ancient scepticism are, it does appear that their reasoning on the subject of causation had some resemblance to that of Mr Hume. Αναιρουσι δε το αιτιον ὡδε· το αιτιον των προς τι εστι, προς γαρ τῳ αιτιατῳ εστι· τα δε προς τι επινοειται μονον ὑπαρχει δε ου· και το αιτιον ουν επινοοιτο αν μονον. (*Ibid.* ix. sect. 97.) It is perhaps impossible to translate the important technical expression τα προς τι. It comprehends two or more things as related to each other—both the relative and correlative taken together as such. Fire considered as having the power of burning wood is το προς τι. The words of Laertius may therefore be nearly rendered into the language of modern philosophy as follows: “Causation they take away thus. A cause is so only in relation to an effect. What is relative is only conceived, but does not exist. Therefore cause is a mere conception.”

The first attempt to prove the necessity of belief in a divine revelation, by demonstrating that natural reason leads to universal scepticism, was made by Algazel, a professor at Bagdad, in the beginning of the twelfth century of our era; whose work entitled *The Destruction of the Philosopher* is known to us only by the answer of Averroes, called *Destruction of the Destruction.* He denied a necessary connection between cause and effect; for of two separate things, the affirmation of the existence of one does not necessarily contain the affirmation of the existence of the other; and the same may be said of denial. It is curious enough that this argument was more especially pointed against those Arabian philosophers who, from the necessary connection of causes and effects, reasoned against the possibility of miracles; thus anticipating one doctrine of Mr Hume, to impugn another. (Tenneman, *Gesch. der Phil.* VIII. 387.)

The same attempt was made by the learned but unphilosophical Huet, bishop of Avranches (*Quæstiones Alnetanæ*, Caen, 1690, and *Traité de la Foiblesse de l'Esprit Humain*, Amsterdam, 1723). A similar motive urged Berkeley to his attack on Fluxions. The attempt of Huet has been lately renewed by the Abbé Lamennais, in his treatise on *Religious Indifference;* a fine writer, whose apparent reasonings amount to little more than well-varied assertions, and well-disguised assumptions of the points to be proved.

To build religion upon scepticism is the most extravagant of all attempts; for it destroys the proofs of a divine mission, and leaves no natural means of distinguishing between revelation and imposture. The Abbé Lamennais represents authority as the sole ground of belief. Why? If any reason can be given, the proposition must be false; if none, it is obviously a mere groundless assertion.

Note R, p. 372.

Casanova, a Venetian doomed to solitary imprisonment in the dungeons at Venice in 1755, thus speaks of the only books which for a time he was allowed to read. The title of the first was *La Cité Mystique de Sœur Marie de Jesus, appellée d'Agrada.*

"J'y lus tout ce que peut enfanter l'imagination exaltée d'une vierge Espagnole extravagamment dévote, cloitrée, mélancholique, ayant des directeurs de conscience, ignorans, faux, et dévots. Amoureuse et amie très intime de la Sainte Vierge, elle avait reçu ordre de Dieu même d'écrire la vie de sa divine mère. Les instructions nécessaires lui avaient été fournies par le Saint Esprit. Elle commençoit la vie de Marie, non pas du jour de sa naissance, mais du moment de son immaculée conception dans le sein de sa mère Anne. Après avoir narré en détail tout ce que sa divine héroïne fit les neuf mois qu'elle a passé dans le sein maternel, elle nous apprend qu'à l'âge de trois ans elle balayoit la maison, aidée par neuf cents domestiques, tous anges, commandés par leur propre Prince Michel. Ce qui frappe dans ce livre est l'assurance que tout est dit de bonne foi. Ce sont les visions d'un esprit sublime, qui, sans aucune ombre d'orgueil, ivre de Dieu, croit ne révéler que ce que l'Esprit Saint lui inspire." (*Mémoires de Casanova,* IV. 343. Leipsic, 1827.)

A week's confinement to this volume produced such an effect on the author, who, though an unbeliever and a debauchee, was then enfeebled by melancholy, bad air, and bad food, that his sleep was haunted, and his waking hours disturbed by its horrible visions. Many years after, passing through Agrada in Old Castile, he charmed the old priest of that village by speaking of the biographer of the virgin. The priest showed him all the spots which were consecrated by her presence, and bitterly lamented that the Court of Rome had refused to canonize her. It is the natural reflection of the writer, that the book was well qualified to turn a solitary prisoner mad, or to make a man at large an atheist. It ought not to be forgotten, that the inquisitors of state at Venice, who proscribed this book, were probably of the latter persuasion. It is a striking instance of the infatuation of those who, in their eagerness to rivet the bigotry of the ignorant, use means which infallibly tend to spread utter unbelief among the educated. The book is a disgusting, but in its general outline seemingly faithful, picture of the dissolute manners spread over the Continent of Europe in the middle of the eighteenth century.

NOTE S, p. 374.

"The Treatise on the Law of War and Peace, the Essay on Human Understanding, the Spirit of Laws, and the Inquiry into the Causes of the Wealth of Nations, are the works which have most directly influenced the general opinion of Europe during the two last centuries. They are also the most conspicuous landmarks in the progress of the sciences to which they relate. It is remarkable that the defects of all these great works are very similar. The leading notions of none of them can, in the strictest sense, be said to be original, though Locke and Smith in that respect surpass their illustrious rivals. All of them employ great care in ascertaining those laws which are immediately deduced from experience, or directly applicable to practice; but apply metaphysical and abstract principles with considerable negligence. None pursues the order of science, beginning with first elements, and advancing to more and more complicated conclusions; though Locke is perhaps less defective in method than the rest. All admit digressions which, though often intrinsically excellent, distract attention, and break the chain of thought. None of them is happy in the choice, or constant in the use, of technical terms; and in none do we find much of that rigorous precision which is the first beauty of philosophical language. Grotius and Montesquieu were imitators of Tacitus,—the first with more gravity, the second with more vivacity; but both were tempted to forsake the simple diction of science, in pursuit of the poignant brevity which that great historian has carried to a vicious excess. Locke and Smith chose an easy, clear, and free, but somewhat loose and verbose style—more concise in Locke—more elegant in Smith,—in both exempt from pedantry, but not void of ambiguity and repetition. Perhaps all these apparent defects contributed in some degree to the specific usefulness of these great works; and, by rendering their contents more accessible and acceptable to the majority of readers, have more completely blended their principles with the common opinions of mankind." (*Edinburgh Review*, vol. XXXVI. p. 244.)

NOTE T, p. 379.

Δει δ' ὁυτως, ὡσπερ εν γραμματειῳ ᾡ μηδεν ὑπαρχει εντελεχειᾳ γεγραμμενον· ὁπερ συμβαινει επι του νου. (ARIST. *de Anima*, lib. iii. cap. v. *Opera*, tom. II. p. 50. Paris, 1639.)

A little before, in the same treatise, appears a great part of the substance of the famous maxim, *Nil est in intellectu quod non prius fuit in sensu.* Ἡδε φαντασια κινησις τις δοκει ειναι, και ουκ ανευ αισθησεως γιγνεσθαι. (*Ibid.* 47.)

In the tract on *Memory and Reminiscence* we find his enumeration of the principles of association. Διο και το εφεξης θηρευομεν, νοησαντες απο του νυν η αλλου τινος, και αφ' ὁμοιου η εναντιου, η του συνεγγυς. (*Ibid.* II. 86.) If the latter word be applied to time as well as space, and considered as comprehending causation, the enumeration will coincide with that of Hume. The term θηρευω is as significant as if it had been chosen by Hobbes. But it is to be observed, that these principles are applied only to explain memory.

Something has been said on the subject, and something on the present writer, by Mr Coleridge, in his unfortunately unfinished work called *Biographia Literaria*, chap. v., which seems to justify, if not to require, a few remarks. That learned gentleman seems to have been guilty of an oversight in quoting as a distinct work the *Parva Naturalia*, which is the collective name given by the scholastic translators to those treatises of Aristotle which form the second volume of Duval's edition of his works, published at Paris in 1639. I have already acknowledged the striking resemblance of Mr Hume's principles of association to those of Aristotle. In answer, however, to a remark of Mr Coleridge, I must add, that the manuscript of a part of Aquinas which I bought many years ago (on the faith of a bookseller's catalogue) as being written by Mr Hume, was not a copy of the Commentary on the *Parva Naturalia*, but of Aquinas's own *Secunda Secundæ;* and that, on examination, it proves not to be the handwriting of Mr Hume, and to contain nothing written by him. It is certain that, in the passages immediately preceding the quotation, Aristotle explains recollection as depending on a general law,—that the idea of an object will remind us of the objects which immediately preceded or followed when originally perceived. But what Mr Coleridge has not told us is, that the Stagyrite confines the application of this law *exclusively to the phenomena of recollection alone*, without any glimpse of a more general operation extending to all connections of thought and feeling,—a wonderful proof, indeed, even so limited, of the sagacity of the great philosopher, but which for many ages continued barren of further consequences. The illustrations of Aquinas throw light on the original doctrine, and show that it was unenlarged in his time. "When we recollect Socrates, the thought of Plato occurs 'as like him.' When we remember Hector, the thought of Achilles occurs 'as contrary.' The idea of a father is followed by that of a son 'as near.'" (AQUIN. *Opera*, I. pars ii. p. 62, *et seq.*) Those of Ludovicus Vives, as quoted by Mr Coleridge, extend no farther.

But if Mr Coleridge will compare the parts of Hobbes on *Human Nature* which relate to this subject, with those which explain general terms, he will perceive that the philosopher of Malmesbury builds on these two foundations a general theory of the human understanding, of which reasoning is only a particular case. In consequence of the assertion of Mr Coleridge, that Hobbes was anticipated by Descartes in his excellent and interesting discourse on *Method*, I have twice reperused that work in quest of this remarkable anticipation, though, as I thought, well acquainted by my old studies with the writings of that great philosopher. My labour has, however, been vain. I have discovered no trace of that or of any similar speculation. My edition is in Latin by Elzevir, at Amsterdam, in 1650, the year of Descartes's death. I am obliged, therefore, to conjecture that Mr Coleridge, having mislaid his references, has, by mistake, quoted the discourse on *Method*, instead of another work; which would affect his inference from the priority of Descartes to Hobbes. It is not to be denied, that the opinion of Aristotle, repeated by so many commentators, may have found its way into the mind of Hobbes, and also of Hume; though neither might be aware of its source, or even conscious that it was not originally his own. Yet the very narrow view of association by Locke, his apparently treating it as a novelty, and the silence of common books respecting it, afford a presumption that the Peripatetic doctrine was so little known, that it might have escaped the notice of these philosophers, one of whom boasted that he was unread, and the other is not liable to the suspicion of unacknowledged borrowing.

To Mr Coleridge, who distrusts his own power of building a bridge by which his ideas may pass into a mind so differently trained as mine, I venture to suggest, with that sense of his genius which no circumstance has hindered me from seizing every fit occasion to manifest, that more of my early years were employed in contemplations of an abstract nature, than of those of the majority of his readers; that there are not, even now, many of them less likely to be repelled from doctrines by singularity or uncouthness; more willing to allow that every system has caught an advantageous glimpse of some side or corner of the truth; more desirous of exhibiting this dispersion of the fragments of wisdom by attempts to translate the doctrine of one school into the language of another;—who, when he cannot discover a reason for an opinion, considers it as important to discover the causes of its adoption by the philosopher; believing, in the most unfavourable cases, that one of the most arduous and useful researches of mental philosophy is to explore the subtile illusions which enable great minds to satisfy themselves by mere words, before they deceive others by payment in the same counterfeit coin. These habits, together with the natural influence of my age and avocations, lead me to suspect that in speculative philosophy I am nearer to indifference than to an exclusive spirit. I hope that it can neither be thought presumptuous nor offensive in me to doubt, whether the circumstance of its being found difficult to convey a metaphysical doctrine to a person who, at one part of his life, made such studies his chief pursuit, may not imply either error in the opinion, or defect in the mode of communication.

Notes and Illustrations.

Note V, p. 395.

A very late writer, who seems to speak for Mr Bentham with authority, tells us that " the first time the phrase of ' the principle of utility' was brought decidedly into notice, was in the ' Essays, by David Hume,' published about the year 1742. In that work it is *mentioned* as the *name* of a principle which *might* be made the foundation of a system of morals, in *opposition to a system then in vogue, which was founded on what was called the ' moral sense.'* The ideas, however, there attached to it, are *vague*, and *defective in practical application*." (*Westminster Review*, No. xxi.) If these few sentences were scrutinized with the severity and minuteness of Bentham's *Fragment on Government*, they would be found to contain almost as many misremembrances as assertions. Utility is not " *mentioned*," but fully discussed, in Mr Hume's Discourse. It is seldom spoken of by " name." Instead of charging it with " *vagueness*," it would be more just to admire the precision which it combines with beauty. Instead of being " *defective in practical application*," perhaps the desire of rendering it popular has crowded it with examples and illustrations taken from life. To the assertion that " *it was opposed to the moral sense*," no reply can be needful but the following words extracted from the Discourse itself: " I am apt to suspect that reason and *sentiment* concur in almost all moral determinations and conclusions. *The final sentence* which pronounces *characters and actions amiable or odious*, probably depends *on some internal sense or feeling, which nature has made universal in the whole species*." (*An Enquiry concerning the Principles of Morals*, sect. i.) The phrase " made universal," which is here used instead of the more obvious and common word " implanted," shows the anxious and perfect precision of language, by which a philosopher avoids the needless decision of a controversy not at the moment before him.

Notes and Illustrations.

Note W, p. 396.

A writer of consummate ability, who has failed in little but the respect due to the abilities and character of his opponents, has given too much countenance to the abuse and confusion of language exemplified in the well-known verse of Pope,

> Modes of self-love the Passions we may call.

" We know," says he, " no universal proposition respecting human nature which is true but one—that men always act from self-interest." (*Edinburgh Review*, March 1829.) It is manifest from the sequel, that the writer is not the dupe of the confusion; but many of his readers may be so. If, indeed, the word *self-interest* could with propriety be used for the gratification of every prevalent desire, he has clearly shown that this change in the signification of terms would be of no advantage to the doctrine which he controverts. It would make as many sorts of self-interest as there are appetites, and it is irreconcilably at variance with the system of association embraced by Mr Mill. To the word *self-love* Hartley properly assigns two significations: 1. Gross self-love, which consists in the pursuit of the greatest pleasures, from all those desires which look to individual gratification; or, 2. refined self-love, which seeks the greatest pleasure which can arise from all the desires of human nature,—the latter of which is an invaluable, though inferior principle. The admirable writer whose language has occasioned this illustration, who at an early age has mastered every species of composition, will doubtless hold fast to simplicity, which survives all the fashions of deviation from it, and which a man of a genius so fertile has few temptations to forsake.

END OF THE SECOND DISSERTATION.

DISSERTATION THIRD:

EXHIBITING A GENERAL VIEW

OF THE

RISE, PROGRESS, AND CORRUPTIONS

OF

CHRISTIANITY.

BY THE

MOST REV. RICHARD WHATELY,
ARCHBISHOP OF DUBLIN.

DISSERTATION THIRD.

INTRODUCTION.

A sketch, like the present, of the rise, progress, and corruptions of Christianity, would be altogether defective without some notice of those religious systems which it was designed to supplant or to complete.

Not only will much light be thrown upon its genuine character and excellence by a contrast with their errors or deficiencies, but moreover, a knowledge of these will often disclose to us the sources of some of those corruptions which have disfigured the simplicity of the Gospel.

The earliest history of mankind, by far, that we possess, is that contained in the Book of Genesis. It is extremely brief and scanty; especially the earliest portion of it. But it plainly represents the first of the human race, when in the Garden of Eden, as receiving direct communications from God. We have no detailed account, however, of the instruction they received; and even part of what the history does record is but obscurely intimated. For example, it is rather hinted than expressly stated, that the use of language was imparted to them by revelation. This, however, is generally understood to be the meaning of the passage (Gen. ii. 20), in which it is said that God brought unto Adam the beasts and birds, to see what he would call them, and that Adam gave them names.

But our first parents, or their children, must have received direct from God a great deal of instruction of which no particulars are related. For besides being taught something of religious and moral duty (Gen. ii. 16; iv. 7), it is evident that they must have learned something of the arts of life. The first generations of mankind were certainly not left at all in the condition of mere *savages*, subsisting on such wild fruits and animals as they might chance to meet with. We read concerning the first two sons of Adam, that the one was occupied in tilling the ground, and the other in keeping cattle.

And even independently of the Bible history, we might draw the same conclusion from what is matter of actual experience, and as it were before our eyes at this day. For it appears that mere savages, if left to themselves without any instruction, never did, and never can, civilise themselves. And, consequently, the *first* of the human race that did acquire any degree of civilisation, since they could not have had instruction from other *men*, must have had a superhuman instructor. But for such an instructor, all mankind would have been savages at this day. The mere fact that civilised men do exist, is enough to prove, even to a person who had never heard of the Bible, that, at some time or other, men must have been taught something by a superior Being: in other words, that there must have been a *revelation*.

It has been indeed not unfrequently maintained that savages can, and sometimes do, invent for themselves, one by one, all the useful arts, and thus raise themselves to a civilised state, without any assistance from men already civilised. One may meet with fine descriptions—though altogether fanciful—of this supposed progress of men towards civilisation. One man, it has been conceived, wishing to save himself the trouble of roaming through the woods in search of wild fruits and roots, would bethink himself of collecting the seeds of these, and cultivating them in a spot of ground cleared and broken up for the purpose. And finding that he could thus raise more than enough for himself, he might agree with some of his neighbours to let them have a part of the produce in exchange for some of the game and fish they might have taken. Another again, it has been imagined, would endeavour to save himself the labour and uncertainty of hunting, by catching some kind of wild animals alive, and keeping them in an inclosure to breed, that he might have a supply always at hand.

And again, another, it is supposed, might devote himself to the occupation of dressing skins for clothing, or of building huts or canoes, or making various kinds of tools; and might subsist by exchanging these with his neighbours for food. And by thus devoting his chief attention to some one kind of manufacture, he would acquire increased skill in that, and would strike out useful new inventions.

Thus these supposed savages having gradually come to be divided into husbandmen, shepherds, and artisans of various kinds, would begin to enjoy the various advantages of a *division of labour*, and would advance, step by step, in all the arts of civilised life.

Now, all this description is likely to appear plausible, at the first glance, to those who do not inquire carefully, and reflect attentively. But, on examination, it will be found to be contradicted by all history, and to be quite inconsistent with the real character of such beings as savages actually are. In reality, such a process of inventions and improvements as that just described, is what never did, and never possibly can, take place in any savage tribe left wholly to themselves.

All the nations of which we know anything, that have risen from a savage to a civilised state, appear to have had the advantage of the instruction and example of civilised men living among them. Every nation that has ever had any tradition of a time when their ancestors were savages, and of the first introduction of civilisation among them, always represent some foreigner or some Being from heaven as having first taught them the arts of life.

Thus the ancient Greeks, we know, attributed to Prometheus the introduction of the use of fire. And agriculture and other arts were popularly supposed to have been first introduced into Greece by Triptolemus and Cadmus, and others, strangers from a distant country.

And the Peruvians have a like tradition concerning a person they call Manco Capac, whom they represent as the offspring of the sun, and as having taught useful arts to their ancestors.

On the other hand, there are a great number of savage tribes, in various parts of the world, who have had no regular intercourse with civilised men, but who have been visited by several voyagers, at different times, and in some instances at very distant periods. And it appears from comparing together the accounts of those voyagers, that these tribes remain perfectly stationary; not making the smallest advance towards civilisation.

For example, the people of the vast continent of New Holland, and of the large island of Papua (or New Guinea), who are among the rudest of savages, appear to remain (in those parts not settled by Europeans), in exactly the same brutish condition as when they were first discovered. They roam about the forests in search of wild animals, and of some few eatable roots, which they laboriously dig up with sharpened sticks. But though they are often half-starved, and though they have to expend as much toil for three or four scanty meals as would suffice for breaking up and planting a piece of ground that would supply them for a year, it has never occurred to them to attempt cultivating these roots.

The inhabitants, again, of the islands of Andaman, in the eastern ocean, appear to be in a more degraded and wretched state than even the New Hollanders.

And to add but one instance more, the New Zealanders, in the interval of above one hundred and twenty-five years between the first discovery of their islands by Tasman, and the second discovery by Captain Cook, seem to have made no advances whatever, but to have remained just in the same condition. And yet they were in a far less savage state than that of the New Hollanders, being accustomed rudely to cultivate the ground, and raise crops of sweet potatoes.

And such appears to be, from all accounts, the condition of all savage, or nearly savage, tribes. They seem never to *invent* anything, or to make any effort to improve; so that what few arts they do possess (and which, in general, are only such as to enable them just to support life), must be the remnant that they have retained from a more civilised state, from which their ancestors had degenerated.

When, indeed, men have arrived at a certain stage in the advance towards civilisation (far short of what exists in Europe), it is then possible for them, if nothing occurs to keep them back, to advance further and further towards a more civilised state.

And this it is that misleads some persons in their notions respecting savages. For finding that there is no *one* art which might not have been invented by unassisted man, *supposing him to have a certain degree of civilisation to start from*, they hence conclude that unassisted man might have invented *all* the arts, supposing him *left originally in a completely savage state.* But this is contradicted by all experience; which shews that men, in the condition of the lowest savages, never have made the first step towards civilisation, without some assistance from without.

Human society may be compared to some combustible substances which will not take fire spontaneously, but when once set on fire will burn with continually increasing force. A community of men requires, as it were, to be kindled, and requires no more.

What, perhaps, contributes most to the erroneous views referred to above, is, that when one tries to fancy himself in the situation of a savage, it occurs to him that he would set his mind to work to contrive means for bettering his condition, and that he might perhaps hit upon such and such useful inventions; and hence he may be led to think it natural that savages should do so, and that some tribes of them may have advanced themselves, in the way above described, without any external help. But nothing of the kind appears to have ever really occurred; and what leads some persons to fancy it, is, that they themselves are *not* savages, but have some degree of mental cultivation, and some of the habits of thought of civilised men; and, therefore, they form to themselves an incorrect notion of what a savage really is—just as a person who possesses eyesight cannot understand correctly the condition of one born blind.

But those who have seen a good deal of real savages, have observed that they are not only feeble in mental powers, but also sluggish in the use of such powers as they have, except when urged by pressing want. When not thus urged, they pass their time either in perfect inactivity, or else in dancing, or decorating their bodies with paint, or with feathers and shells, or in various childish sports. They are not only brutishly stupid, but still more remarkable for childish thoughtlessness and improvidence. So that it never occurs to them to consider how they may put themselves in a better condition a year or two hence.

Now, such must have been the condition of all mankind down to this day, if they had all been, from the first, left without any instruction, and in what is called a *state of nature*—that is, with the faculties man is born with, not at all unfolded or exercised by education. For from such a state, unassisted Man cannot, as all experience shews, ever raise himself. And consequently, in that case, the whole world would have been peopled with mere savages in the very lowest state of degradation. The very existence, therefore, at this day, of civilised men, proves that there must have been, at some time or other, some instruction given to Man in the arts of life, by some Being superior to Man. For, since the *first beginnings* of civilisation could not have come from any *human* instructor, they must have come from one *super*human.

It has been shewn, then, that the whole world would now have been peopled with the very lowest savages, if men had never received any instruction, and yet had been able to subsist at all. But it is doubtful whether even this bare subsistence would have been possible. It is more likely that the first generation would all have perished for want of those few arts which even savages possess, and which (as has been above remarked) were probably not *invented* by savages, but are remnants which they have retained from a more civilised state. The knowledge, for instance, of wholesome and of poisonous roots and fruits, the arts of making fish-hooks and nets, bows and arrows, or darts, and snares for wild animals, and of constructing rude huts and canoes, and some other such simple arts, are possessed, more or less, by all savages, and are necessary to enable them to support their lives. And it is doubtful whether men left completely in a state of nature—that is wholly untaught—would not all perish before they could invent them for themselves.

For we should remember that Man, when left in a state of nature, untaught, and with his rational powers not unfolded, is far less fitted for supporting and taking care of himself than the brutes. *They* are much better provided both with *instincts*, and with bodily *organs* for supplying their own wants. For example, those animals that have occasion to dig, either for food or to make burrows for shelter—such as the swine, the hedgehog, the mole, and the rabbit, have both an *instinct* for digging, and snouts or paws far better adapted for that purpose than man's hands. Yet man is enabled to turn up the ground much better than any brute; but then this is by means of *tools* which man can be taught to make and use, though brutes cannot. Again, birds and bees have an instinct for building such nests and habitations as answer their purpose as well as the most commodious beds and houses made by men; but Man has no instinct that teaches him how to construct these. Brutes, again, know by instinct their proper food, and avoid what is unwholesome; but man has no instinct for distinguishing the nightshade-berry (with which children have been so often poisoned), from wholesome fruits. And quadrupeds swim by nature, because their swimming is the same motion by which they advance when on land; but a man, falling into deep water, is drowned, unless he has *learnt* to swim.

It appears, then, very doubtful whether men left wholly untaught, would be able to subsist at all, even in the state of the lowest savages. But, at any rate, it is plain they could never have risen *above* that state. And, consequently, the existence of civilisation at this day is a kind of *monument* attesting the fact that some instruction from above must, at some time or other, have been supplied to mankind. And the most probable conclusion is, that Man, when first created, or very shortly afterwards, was advanced by the Creator Himself, to a state above that of a mere savage.

Now this is exactly what is related in Scripture. But it must be remembered that the proof which has been just given of an original revelation to Man, is quite independent of the Bible history; and, therefore, tends to confirm that history. That Man could not have *made* himself, is appealed to, as a proof of a divine *Creator*. And that mankind could not, in the first instance, have *civilised* themselves, is a proof exactly of the same kind, and equally strong, of a superhuman *Instructor*.

And here the inquiry may perhaps be raised, how it ever came about that various tribes of men, from time to time, degenerated into the savage state. We have no distinct records of the progress of this degeneracy; nor, from the nature of the case, is it possible that we should. But, no doubt, *wars* have always been the principal cause of it. When men were continually harassed by a superior force of ferocious enemies, who hunted them down like wild beasts, and burnt their dwellings, and laid waste the country, they would be driven to shelter themselves in forests, and deserts, and mountains; and would have no opportunity of practising, or of teaching to their children, most of the arts they might be acquainted with. Agriculture, for instance, would necessarily be abandoned. And being entirely occupied in a struggle for bare subsistence, and in providing for defence against their enemies, or for escape, they would have neither leisure, nor means, nor inclination, for keeping up the various arts of civilised life. These, therefore, would, in two or three generations, be forgotten and irrecoverably lost among them; and the whole character of the people would have degenerated.

We have said, that from the very nature of the case, it is impossible we should have any distinct accounts of the progress of this degradation, since men so situated would not compose histories. But it is remarkable that in several savage tribes, there are some faint traditions of their ancestors having formerly come from some distant and better country; doubtless driven out by war.

It is likely that the instruction in the arts of life that was originally bestowed on the human race was merely sufficient to give them a *beginning;* to advance them just so far towards civilisation as to enable them, thenceforward, to advance themselves, and to invent, one by one, by the exercise of their own faculties, various arts, according to their wants and opportunities.

The Bible history informs us of hardly any particulars, either of what was originally taught to mankind, or of their own inventions. We have only a very brief and slight hint of the invention of the art of working metals, and of musical instruments, and perhaps, also of tents. (Gen. iv. 20.) But, doubtless, many other arts were invented before the Flood.

Several of the most important arts, and of those most generally known throughout the world, must have been very ancient; and as their first introduction is not mentioned in the Bible, there is no record or tradition of it. And we are so familiar with these that we are apt to regard them as more simple and obvious than they are; though, on reflection, it will appear that some of them were most likely invented gradually, and by successive steps taken at long intervals.

And here it is worth observing how important an advantage, in reference to the invention of arts, would have been afforded to men in a very early and rude state of society, by their possessing (as Scripture informs us the earliest of them did) a very long continuance of life. In the present day, an ingenious and observant man *writes* down, and generally prints and publishes the experiments and observations he has made; and thus those who come after him are enabled to follow up his inquiries and attempts, so that each generation improves upon the last. But before the use of printing and writing, the chief part of each man's experience would be lost to those who came after him. In those early days, therefore, it was of vast importance, with a view to the invention of arts, that each man should be enabled, by great length of life, to apply his own experience, and to follow up himself the discoveries he might have made.

We have no direct information as to the immediate cause of the great longevity of the earliest generations of men. But it seems likely that it may have been produced by the influence of "*the Tree of Life.*"[1]

That the produce of this tree (whether its fruits or its leaves) was endued by the Creator with some property of warding off death, we are plainly taught, both by its name and by the exclusion of Adam from the Garden of Eden, "lest he should eat of the tree of life, and live for ever."

It is likely that it had the medicinal virtue, when applied from time to time, of preventing or curing the decays of old age; just as our ordinary food preserves men from dying of exhaustion by famine; and as several well-known medicines prevent or cure certain diseases. We know, indeed, that there does not exist now any medicine that has the virtue of keeping up or renewing youthful health or vigour. But such a medicine would not be in itself at all more strange than many things which we are familiar with, but whose effects we cannot explain, and could never have conjectured.

For example, that opium and some other drugs should produce sleep, and strong liquors a kind of temporary madness, is what no one would ever have thought of, if he had never heard of it, nor seen the experiment tried, of swallowing those substances. Nor, even if he were a skilful chemist, would he be able, by analysing them, to conjecture what their effects would be. If, then, the Tree of Life were such a medicine as we have supposed, a person who always continued the use of it from time to time, would continue exempt from decay and death.

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[1] It appears to be a vestige of an early tradition respecting the use of the Tree of Life, that Homer represents his gods as supporting perpetual life and vigour by drinking nectar and *eating Ambrosia, i. e.* (immortality.)

But supposing some persons who had been in the habit of using it (as our first parents doubtless had, since there was nothing to prevent them) should afterwards *cease* to use it, their constitution would probably have been so far fortified, that though they would at length die, yet they would live much *longer* than man's natural term. And they would even be likely to transmit to their descendants such a constitution as would confer on those also a great degree of longevity, which would only wear out gradually in many successive generations.

Now, it is remarkable that this exactly agrees with what we do find recorded. If we look into those parts of the Bible history which relate to this subject, we shall find Man's life in the earliest generations extending to eight or nine centuries, and upwards. And we shall find longevity gradually diminishing in each generation, down to the times of Abraham, Isaac, and Jacob, who lived rather less than two hundred years; and again down to the time of Moses, who began his mission, apparently in the full vigour of life, at fourscore, and lived to one hundred and twenty. Joshua, who succeeded him, lived one hundred and ten years. And from thenceforward human life appears to have been brought down to about its present limit.

The above seems to be the most clear, easy, and natural interpretation of those parts of Scripture we have been examining. There is not, however, any such distinct revelation on the subject as to authorise our pronouncing confidently that such must be the right interpretation, and making this an article of faith.

With respect to religious instruction, although, as has been said, the Maker and Governor of all things did certainly make Himself known to the earliest generations of mankind, and accepted worship from them; we are told very few particulars of the revelations that were made. We find, indeed, a prophecy made to Adam and Eve, just before their expulsion from Paradise: that the seed of the woman should bruise the serpent's head. But whether any explanation was given them, of the reference this had to our Saviour's triumph over Satan and Death, we are not told. And it is even a matter of doubt among the learned, whether the sacrifices (Gen. iv. viii.) that were offered up in the earliest times, and afterwards by Noah, were of express divine appointment, or were merely a mode of worship which men devised of themselves, and which God thought fit to approve and accept. And there is nothing so distinctly said in Scripture on the subject, as to authorise any one to decide confidently, one way or the other. If it had been necessary that we should have any certainty as to this point, doubtless we should have had some plain declarations upon it.

Of Enoch we find it recorded, that he "walked with God," that is, led a life of eminent holiness, and was so far favoured, as to be withdrawn from the earth without tasting of death. And he is referred to, in the Epistle to the Hebrews, as an example of *faith*, inasmuch as "without faith it is impossible to please God." But as to the *subjects* of his faith, the Apostle himself seems to have had no distinct and particular knowledge, except that he must have believed in the existence and in the goodness of God,—"For he that cometh to God must believe that He is; and that He is a rewarder of them that diligently seek Him."

Of course what is meant in this passage by the word "God," is—what we also understand by it—the Creator of the world. We cannot doubt that He must have made Himself known to the earliest of mankind, as the Maker of themselves, and of all things around them. And the account given in Genesis, of the creation, and of some other of the earliest events, is probably a tradition of this most ancient revelation, and was very likely committed to writing, long before the time of Moses.

Some persons have imagined that we are bound to take our notions of Astronomy, and of all other Physical Sciences, from the Bible. And accordingly, when astronomers discovered and proved that the earth turns round on its axis, and that the sun does not move round the earth, some cried out against this as profane, because Scripture speaks of the sun's rising and setting. And this probably led some astronomers to reject the Bible, because they were taught that if they received *that* as a divine revelation, they must disbelieve truths which they had demonstrated.

So also, some have thought themselves bound to believe, if they receive Scripture at all, that the earth, and all the plants and animals that ever existed on it, must have been created within six days, of exactly the same length as our present days. And this, even before the sun, by which we measure our days, is recorded to have been created. Hence, the discoveries made by geologists, which seem to prove that the earth and various races of animals must have existed a very long time before Man existed, have been represented as completely inconsistent with any belief in Scripture.

We may not stop to discuss the various objections (some of them more or less plausible, and others very weak), that have been brought—on grounds of science, or supposed science—against the Mosaic accounts of the creation, of the state of the early world, and of the flood, and to bring forward the several answers that have been given to those objections. But it is important to lay down the PRINCIPLE on which either the Bible or any other writing or speech ought to be studied and understood, viz., with a reference to *the object proposed* by the writer or speaker.

For example, if we bid any one proceed in a straight line from one place to another, and to take care to arrive before the sun goes down, he will rightly and fully understand us, in reference to the practical object which alone we had in view. Now, we know that there cannot really be *a straight line* on the surface of the earth; and that the sun does not really *go down*, only our portion of the earth is turned away from it. But whether the other party knows all this or not, matters nothing to our present object; which was not to teach him mathematics or astronomy, but to make him conform to our directions, which are equally intelligible to the learned and the unlearned.

Now, the object of the Scripture revelation is to teach men, not astronomy or geology, or any other physical science, but *Religion*. Its design was to inform men, not *in what manner* the world was made, but WHO made it; and to lead them to worship Him, the Creator of the heavens and the earth, instead of worshipping his creatures, the heavens and earth themselves, as gods; which is what the ancient heathen actually did.

Although, therefore, Scripture gives very scanty and imperfect information respecting the earth and the heavenly bodies, and speaks of them in the language and according to the notions of the people of a rude age, still it fully effects the object for which it was given, when it teaches that the heavens and the earth are not gods to be worshipped, but that "*God created the heavens and the earth*," and that it is He who made the various tribes of animals, and also Man.

But as for astronomy and geology and other sciences, men were left, when once sufficiently civilised to be capable of improving themselves, to make discoveries in them by the exercise of their own faculties.

But whatever may have been the religious instruction originally afforded to mankind, most of them appear not to have made the proper use of their advantages; but to have fallen, in very early times, into idolatry and superstitions of various kinds.

Whether false religion was introduced before the flood, we are not expressly told; but there is every reason to think it must have been. For we read that mankind had become excessively wicked, and that this brought on them that terrible judgment. And all experience shews that great moral depravity and gross religious corruption accompany each other. Moral corruption favours the introduction of corrupted and false religious notions; and a false religion, in turn, favours immorality.

Moreover, there is a passage in Genesis (chap. iv. 26), which, though it be but an obscure hint, seems to relate to the first introduction of false gods, in the times of Enos, grandson of Adam, and apparently about three or four centuries after the creation. The passage is translated in the text of our version, " Then began men to call upon the name of the Lord: אָז הוּחַל לִקְרֹא בְּשֵׁם יְהוָֹה. (Gen. iv. 26.) But the translation in the margin is " Then began men to call themselves by the name of the Lord." And some learned men translate it, " Then began men to call the Lord by name."

The sense of the passage certainly cannot be that divine worship was then introduced for the first time; which, we know, from the preceding history (ch. iv. 3), was not the case. But it probably means that, then, those who worshipped the true God, began to apply to Him some distinct name or title, such as *Adonai* or *Jehovah*, to distinguish Him from the pretended gods worshipped by others, and that they called themselves " by his name," that is, described themselves as his worshippers, to distinguish themselves from those who served other gods. As long as one God only was acknowledged in the world, there was no need to apply to Him any distinguishing title. But when the worship of other Beings was introduced, it would be necessary for the true worshippers to mark the distinction. It is probable, therefore, that this was the time when such false worship first became prevalent.

In later times, we know, false religions did prevail very extensively, as indeed they still do, among a large portion of mankind.

We shall next consider what was the real character of the Pagan religions, and in what way it is likely they were introduced.

THE PAGAN RELIGIONS.

THE worshippers of false gods, such as the greater part of mankind formerly were, are usually called *Heathens* or *Pagans*. The word *Heathen* as well as the word *Gentiles*, which had the same meaning, signified originally *Nations*. But since all, or nearly all, nations except the Jews (who called themselves the Lord's *People*) were worshippers of false gods, hence the word " Heathen"[1] came to be used as it is now. And the word " Pagan" also, which originally signified a *Villager*, came to be used in the same sense; because, in the early times of Christianity, many of the inhabitants of retired country villages retained their old superstitions, after the inhabitants of the *towns* had been converted to the Gospel.

There are some persons, who, though possessing a considerable knowledge of things connected with Mythology, yet mistake altogether the real character of the Pagan religions. They sometimes imagine that all men, in every age and country, had always designed to worship one Supreme God, the maker of all things;[2] and that the error of the Pagans consisted merely in the false accounts they gave of Him, and in their worshipping other inferior gods besides.

But this is altogether a mistake. Few, if any, of the ancient Pagans ever thought of worshipping a Supreme Creator at all. Those who believed, or suspected, that the world had been created, never pretended that it was the work of any of the gods they worshipped.[3] Many held that the world was not created, but eternal; and others maintained that though it had a beginning, it was the production of what they called chance; that is, they fancied that the particles of matter of which the world consists, moved about at random, and accidentally fell into the shape it now bears.

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[1] This is the commonly received etymology, though some think it is derived from the German " Heiden," inhabitant of a " heath" or wilderness.

[2] *See* POPE'S *Universal Prayer*.

" Father of all, in every age,
In every clime adored;
By saint, by savage, and by sage,
Jehovah, Jove, or Lord."

[3] Sic ubi dispositam *quisquis fuit ille Deorum* Congeriem secuit, sectamque in membra redegit, &c. &c.—*Ovid. Metam.* 1.

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These persons were what we should call *Atheists.* For by the word GOD, we understand an Eternal Being, who made and who governs all things. And if any one should deny that there *is* any such Being, we should say that he was an Atheist; even though he might believe that there do exist Beings *superior to man;*[1] such as the Fairies and Genii in whom the uneducated in many parts of Europe still believe.

Accordingly, the Apostle Paul (Eph. ii. 12) expressly calls the ancient Pagans Atheists (ἄθεοι), though he well knew that they worshipped certain supposed superior Beings which they called gods. But he says in the Epistle to the Romans, that they "worshipped the creature more than[2] (*i. e.* instead of) the Creator." And at Lystra (Acts xiv. 15), when the people were going to do sacrifice to him and Barnabas, mistaking them for two of their gods, he told them to "turn from these vanities to serve the *living* God, *who made heaven and earth.*"

This is what is declared in the first sentence of the Book of Genesis. And so far were the ancient Pagans from believing that "in the beginning God made the heavens and the earth," that, on the contrary, the heavens, and the earth, and the sea, and many other natural objects, were among *the very gods they adored.*

The heavens—that is the sky, the atmosphere around us—they worshipped under the titles of Zeus or Dis—of Jupiter or Jove—and (among the Canaanites and Babylonians) of Baal, Bel, or Belus.[3] They worshipped the earth also under the names of Demeter and Cybele; called by our Anglo-Saxon ancestors Hertha (whence our words "earth" and "hearth"), and by them most especially venerated.

The Pagans also worshipped the sea, under the title of Neptune; the sun, under that of Phœbus or Apollo; and the moon, under that of Diana. These last they called the son and daughter of Jove; meaning that the sun and moon were produced by the heavens.

The Egyptians also worshipped the same kind of gods, and, among others, the great river Nile, on which the fertility of their country depends. The plagues which the Lord sent on Egypt (Exod. xii. 12) when he delivered the Israelites, seem to have been partly designed to prove his superiority and dominion over these pretended gods, by making them the very instruments of his judgments. Their *river* was turned into blood; the *earth* brought forth a plague of frogs; the *sky*, or atmosphere which they worshipped, sent forth destructive hail and lightning; and the *sun* was darkened. This was a useful lesson, both to the Israelites and to the Egyptians themselves, as many as would learn from it.

The ancient Pagans seem to have supposed that certain living spirits resided in, and ruled over, the air, the sun, moon, earth, and sea. And besides these, they also worshipped a number of other supposed Beings who presided over the several passions, and faculties, and actions of man. Thus Minerva was the goddess of wisdom; and Mars the god of war: and they often used the word Minerva to signify *intelligence*, and Mars to signify *valour.* So Hermes (or Mercury) was supposed to preside over *traffic*, and also over *eloquence.* And thence it was that the Lystrans "called Paul 'Mercurius,' because he was the chief speaker." (Acts xiv. 12.)

None of the ancient Pagans considered any of their gods as *eternal.* They generally supposed them *immortal*—that is, exempt from *death;*

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[1] "Now, suppose that any one in those ages had denied the existence of God and his angels, would not his impiety justly have deserved the appellation of Atheism, even though he had still allowed, by some odd capricious reasoning, that the popular stories of elves and fairies were just and well-grounded. The difference, on the one hand, between such a person and a genuine *Theist*, is infinitely greater than that on the other between him and one who absolutely excludes all invisible intelligent power. And it is a fallacy merely from the casual resemblance of names, without any conformity of meaning, to rank such opposite opinions under the same denomination. To any one who considers justly of the matter, it will appear that the gods of all *Poly*theists are no better than the elves or fairies of our ancestors, and merit as little any pious worship or veneration. These pretended religionists are really a kind of superstitious Atheists, and acknowledge no Being that corresponds to our idea of a deity."—HUME's *Natural History of Religion*, sec. 4.

[2] παρὰ τὸν κτίσαντα.

[3] Διὸς Βήλȣ. Herodotus.

but, for the most part, they had some tradition about the *birth* of each of them. Indeed, several of them were confessedly dead men, whom they imagined to have been raised to the ranks of the gods by their great deeds on earth. Thus Romulus, the founder of Rome, was worshipped by the Romans under the title of Quirinus. And Hercules, and many others, worshipped by the ancient Pagans, were deified men, supposed to have gained immortality, by their eminent virtues, and especially by their feats of war.

The Northern nations, however, thought that the gods they worshipped were not immortal, but doomed finally to perish, after a very long life.[1] These gods, nevertheless, are supposed, most of them, to have answered to the Greek and Roman gods, though with different names. Of these names we have still a kind of record in the names of the days of the week, which were dedicated by our Pagan forefathers, each to one of their gods.[2] Many of the Jews, and of the early Christians, seem not to have disbelieved the *existence* of the heathen gods, but to have considered them as evil demons whom it was impious to worship. They did, indeed, often deride the Heathen for worshipping images, " the work of men's hands, wood and stone." (Isa. xliv.) But it is plain that any one who so worships, must believe that there is some living spirit residing in the image, or somehow connected with it. For no one *could* pay adoration to a mere stone, believing it himself to be nothing more than a mere stone. And it appears that many of the Jews and early Christians believed the Beings that were represented by the heathen idols to be demons. Thus we find the Jews calling Beelzebub the prince of the demons, and blasphemously attributing to him the miracles of our Lord. Now Beelzebub was the Philistine god of Ekron. (2 Kings i.)

And certainly the character which the Pagans attributed to their gods, was very much that of evil demons. The very best of these gods were represented by them as capricious and profligate tyrants, whom they worshipped more from fear than love. One, in particular, who was especially dreaded, was Pan, the god of shepherds. In particular, they attributed to him all sudden and unaccountable terrors, such as sometimes seize armies or other large bodies of men, and which have thence received the name of Panic. Their images represent him as partly in the human form, and partly in that of a goat, with horns and cloven hoofs. And hence it is, that by a kind of tradition, we often see, even at this day, representations of Satan in this form. For, the early Christians seem to have thought that it was *he* whom the Pagans adored under the name of Pan.

This is certain, that several savage tribes at this day profess to believe in a *good* god, and an evil one; and address all their worship, and offer their sacrifices to the *evil* one. They suppose that the Good Being will, of his own accord, without being asked, do all the good in his power; and all their prayers and offerings are to the Evil one—or to several evil Beings—whose malice they hope to soften.[3]

The images and pictures of the gods of the ancient Egyptians, and of the Hindoos at this day, are usually strange monstrous figures, half man and half brute. And such was the Philistine image of Dagon, which was half man and half fish.[4] The Greeks and Romans, on the contrary, represented the greater part of their deities as handsome men and women; but the image of Pan and some others were exceptions. And the emblem[5] of Diana at Ephesus, which they worshipped as having " fallen down from Jupiter," is said to have been a rude, shapeless stone. It was most likely an aerolite—one of those stones which do really sometimes fall from the sky. So probably, is also the black mass of stone at Mecca, in the Caaba, venerated by the Mahometans. For though Mahomet was opposed to idolatry, he found the veneration of the Arabians for this stone to be so great, that he did not venture to oppose it.

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[1] " Till Lok has burst his tenfold chain;
. . . . till substantial night
Has reassumed her ancient right."—GRAY.

[2] The first day of the week was dedicated, as its name shews, to the sun, and the second to the moon; Tuesday was sacred to Tuisco, the same as the Roman Mars; Wednesday to Woden, who is supposed to be the same with Mercury; Thursday to Thor, that is Jupiter; Friday to Friga, who was the Venus of the Romans; and Saturday to Saturn.

[3] We have an amusing instance of this tendency of the human mind in the anecdote (a true one), of the schoolboy who was observed to bow in church whenever the name of Satan was mentioned; and being asked the reason, replied, " I was afraid he might do me some harm."

[4] The name does actually signify a fish.

[5] In our version (Acts xix.), it is called " the *image* which fell down from Jupiter," but the word " image" is supplied by the translators; the original merely speaks of their being worshippers, τοῦ Διοπετοῦς, of " that which fell down from Jupiter."

As for the kind of worship which the Pagans paid to their gods, it was very much what might have been expected, considering what kind of Beings these gods were, according to their own accounts of them. When Moses is cautioning the Israelites against being led away by the example of their idolatrous neighbours, he says, "Every abomination unto the Lord, which he hateth, have these nations done unto their gods; for even their sons and their daughters, have they burned in the fire unto their gods." And the inhabitants of the South Sea Islands, at this day, offer human victims to their gods; as did also the people of Mexico. The grossest profligacy, and the most atrocious cruelties, were not only not *forbidden* by the Pagan religions, but were even a *part of* their religious worship; especially at the festivals of Bacchus.

And even the best of their gods were supposed to be more gratified by costly offerings and splendid temples, than by a pure and virtuous life in their worshippers. This, indeed, was quite natural; since these gods were described as not only themselves committing the most abominable actions, but as patrons of such actions. Mercury, for instance, was reckoned the god, not only of traffic, but of cheating; and the Romans had a goddess of thieves, called Laverna,[1] who was regularly worshipped, as well as the rest. Mars and Bellona are described as delighting in human carnage. And indeed, there are in modern languages, words still in use, derived from the Pagan religions, and generally signifying something *evil*. For instance, the words Martial, Panic, Bacchanalian, Jovial, and many others that might be added.

As for the notions of the ancient Pagans respecting a future state; the Popular Mythology of the Greeks and Romans did certainly contain ample descriptions of a life after this, and of the places prepared for the reward and punishment respectively of the virtuous and the wicked. It might indeed be urged with truth, that this Mythology, resting as it did on no other evidence than that of vague, and incoherent, and contradictory traditions, could not afford any *rational assurance* of a future state. And such, of course, must be the case with the notions of Pagans of the present day on the subject, as well as with those of the barbarian nations of antiquity, of whose Mythology we have no distinct and authentic accounts. How far the doctrine of a future state did or does prevail as a matter of *serious belief*, in those nations, it is by no means easy to determine on sufficient evidence. In those of modern times it is also difficult, if not impossible, to decide whether, and to what degree, some parts of their religion may have been derived, through a remote and corrupt tradition, from the Gospel. The fairest mode of trying the question, therefore, seems to be, by examining the opinions that prevailed before the promulgation of the Gospel. And these afford, as we have said, no well-founded assurance. Nor again, did the Pagan Mythology inculcate the doctrine of a resurrection; and it was in many other points greatly at variance with what Christians receive as the authentic and true accounts. Still it must be admitted that a system so far correct in its outline, as to contain the notion of a just judgment and a state of retribution hereafter, to be influenced by our conduct during the present life, would in some degree supply the want of the Gospel revelation on these points, provided it were (on whatever evidence) fully and firmly and generally *established* among the mass of the community. But that this was not the case with respect to the accounts of a future state current among the ancients, is the conclusion which will present itself to any one who examines the question fully and candidly. We say fully and candidly, because one whose researches are very limited, will not be unlikely to have met with such passages only in ancient writers as would, of themselves, lead to a contrary conclusion; and one who is strongly prepossessed in favour of that conclusion, will confine his attention to those passages, seeking only to explain away all that militates against it.

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[1] . . . . "Pulchra Laverna,
Da mihi fallere, da justo sanctoque videri;
Noctem peccatis, et fraudibus objice nubem."—HORACE.

The truth is, there *are* many passages to be found (and that frequently in the same authors) of each description; some that seem to imply the general belief, and others the disbelief, of the accounts of a future life. And some have dwelt on the *numerical* superiority of those passages that favour the doctrine; as if a book were to be regarded in the same light as a legislative assembly, in which we have only to *count* the votes on each side, and consider the decision of the majority as that of the whole. But it should be remembered that, in such a case, the expressions which negative the belief, are entitled to far the greater weight. For there can be no doubt that the fables of Elysium and Tartarus were a part of the popular religion, which it was usually thought decorous to speak of with respect: and the doctrine of a future state was regarded as especially expedient to be inculcated on the vulgar, in order to restrain them in cases beyond the control of human laws; so that a good reason can be assigned for a philosopher's appearing to consider the doctrine as indubitable, though he neither believed it himself, nor could flatter himself that it was so generally believed as he might think desirable: whereas, on the other hand, no reason whatever can be assigned for any one's treating it as a fable, if he really did believe it.

When, then, we find Socrates and his disciples represented by Plato as fully admitting, in their discussion of the subject, that "Men in general were highly incredulous as to the soul's future existence," and as expecting that it would at the moment of our natural "death, be dispersed (as he expresses it) like air or smoke, and cease altogether to exist. So that it would require no little persuasion and argument to convince them that the soul can exist after death, and can retain anything of its powers and intelligence." When we find this asserted, or rather alluded to, as notoriously the state of popular opinion, we can surely entertain but little doubt that the accounts of Elysium and Tartarus were regarded as mere poetical fables, calculated to amuse the imagination, but unworthy of serious belief.

Again, the testimony of Thucydides, not as to the *professed* belief, but as to the conduct, of the Athenians, under those trying circumstances in which the near approach of death impresses the most forcibly the thought of a future state on the minds of those who expect it—his testimony, we say, as to their conduct on such an occasion, must alone prove almost decisive of the question. For it will hardly be denied, that those who firmly believe in a future state, or even regard it as a thing highly probable, however the pursuits and occupations of this world may have drawn off their attention from it, will be likely, when death evidently draws near,—death, not in the tumultuous ardour of battle, but in the calm, yet resistless progress of disease,—to think with lively and anxious interest of the life of another world. If they have any apprehensions at all of judgment to come, they will usually wish to "die the death of the righteous," even though they may not have been willing to lead the life of the righteous. Even those who have been in some doubt respecting this truth, or who have studied to keep it out of sight, are often found to believe in it the most firmly at that awful moment, when they would be most glad to disbelieve it, and then to think most of it, when the thought is most intolerable.

It is not necessary for the present purpose to contend that what has been just said constitutes a rule without exception; let it be admitted only as applying to the generality, or even to a considerable portion merely, of mankind (and thus far, at least, we are surely borne out, both by reason and experience); and let any one, with these principles before him, contemplate the picture drawn of the pestilence which ravaged Athens during the Peloponnesian war, by that judicious historian who was an eye-witness, and a partaker of the calamity. Whether the ancient poets or philosophers be regarded as the better instructors in the doctrine of a future state, Athens had no deficiency in either; and a plague so widespreading, so irresistible, and which brought with it to those whom it seized (as we are expressly told), such an utter despair of recovery, may be fairly expected to have had the effect, in some minds at least, of awakening whatever belief, or even suspicion, they might have entertained respecting Tartarus and Elysium, and of calling into action their fears and hopes on the subject.

We might expect to find *some* of them, at least, bewailing their sins, making reparation to those they had injured, and in every way striving to prepare for the judgment that seemed impending.

The very reverse took place. The historian tells us, that "seeing death so near them, they resolved to make the most of life while it lasted, by setting at nought all laws, divine and human, and eagerly plunging into every species of profligacy." Nor was this conduct by any means confined to the most vile and worthless of the community; for he complains of a general and permanent *depravation* of morals, which dated its origin from this calamity. Nor again, does the description apply to such only as had been, either openly or secretly, contemners of the whole system of the national religion; for we are told, that "at first, many had recourse to the offices of their religion, with a view to appease the gods; but that when they found their sacrifices and ceremonies *availed nothing against the disease*, and that the pious and the impious alike fell victims to it, they at once concluded that piety and impiety were altogether indifferent, and cast off all religious and moral obligations." Is it not evident from this, that those who did reverence the gods, had been accustomed to look for none but *temporal* rewards and punishments from them? Can we conceive that men who expected that virtue should be rewarded and vice punished, in the other world, would, just at their entrance into that world, *begin* to regard virtue and vice as indifferent? It is but too true, indeed, that men have been found in countries where Christianity is professed, so hardened, as to manifest, even at the approach of death, no regard to the judgment which Christianity teaches is to succeed it; who have availed themselves of present impunity for the commission of crimes, or have endeavoured to drown thought in sensual excess; but instances of this kind rather go to prove that such men do *not*, than that the heathen *did*, believe in a future retribution; if by belief is to be understood, not a mere unthinking assent, or a mere *non-denial* of the doctrine, but a deliberate, firm, and habitual conviction.

Those who have been long hardened in habits of extreme profligacy, may ultimately become as blind to all ideas of a future state, as if they had never heard of it; but experience, as well as reason, forbids us to believe that, where the Gospel is assiduously preached and accepted, such a degree of ignorance, or of depravity, can ever be general, much less universal.

And accordingly, it appears that the great plague which desolated London, produced, on the whole, an effect exactly opposite to that at Athens. Some abandoned wretches, no doubt, took the same advantage as the Athenians did, of the calamity; but the generality seem plainly to have shewn that their belief of a future state, however it might have lain dormant during a time of apparent security, and however easily it might be thrown off on a return to such a state, was real and deep-rooted. No instances are recorded *there* of pious men *renouncing* their piety when they saw death approaching: on the contrary, serious devotion seems, for the most part, to have prevailed; and if not reformation, at least alarm and contrition, to have been generally produced among sinners. Many are said, when attacked by the plague, to have even rushed into the public streets, confessing aloud and bewailing crimes long ago committed, and never before imputed to them, and earnestly seeking to make reparation.

Can we, then, on comparing two such cases together, come to the conclusion, that in each the notions respecting a future state were the same, or at all similar? Is not the inference obvious, that, at least, the Athenians of that age considered the accounts of a future life as no more than amusing fictions, of whose utter falsity there was no reason even to doubt? And accordingly, when Pericles is represented by the same historian, as exhausting every topic of consolation, in his address to the friends of those who had fallen in battle,[1] he speaks of their glorious memory, and of the hope of other sons to be born, who may fill their place, and emulate their worth, but adds not one word of their future life and immortality.

And that the prevailing belief, at other times, and in other states, Greek or Italian, was the same as at Athens at the period just spoken of, there is at least a strong presumption till evidence of the contrary is produced. The Athenians were noted for their religious devotion; the popular mythology which prevailed among the other Grecian states, and, we may add, at Rome, was the same, or nearly the same, with theirs; and therefore may be presumed, in the absence of all proof to the contrary, to have had the same results in respect of the belief of a future life. Indeed, we find the younger Pliny,[1] in his account of the eruption of Vesuvius, in which his uncle perished, recording, among the striking events of that scene, the excitement of a feeling not unlike that of the Athenians in the plague—viz., a general distrust of divine aid, arising from the notion that the gods themselves were possibly involved in the impending ruin.

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[1] THUCYD., lib. ii., c. 35, *et seq.*

The belief, then, of a life to come, though nominally professed, cannot be considered as practically forming any part of the creed of those ancient nations with whom we are best acquainted. Cicero acknowledges that the epistle of Sulpicius to him on the death of Tullia, comprehended *every* argument for comfort which the case admitted; yet we find in it no allusion to the one topic which would have been uppermost in the mind of a believer. It is no wonder, therefore, that when at Athens, Paul came to speak of the resurrection of the dead, some of his hearers mocked; and that when Festus heard him declaring the same doctrine, he exclaimed, "Paul, thou art beside thyself."

So far, indeed, were the promulgators of Christianity from finding the belief of a future state already well established, that they appear to have had no small difficulty in convincing of this truth even some of their converts. Some of those who denied a *resurrection*, may, indeed, with good reason, be supposed to have looked for some other kind of future existence; but when Paul finds it necessary to urge "*if in this life only we have hope* in Christ, we are of all men most miserable —let us eat and drink, for to-morrow we die,"[2] it is plain he must have been opposing such as expected *nothing* beyond the grave. And when he exhorts the Thessalonians not to sorrow for the deceased, "even as *the rest*[3] (of mankind), who have *no hope*," we have the testimony, if we will receive it, of one who knew better than we can, the real sentiments of the heathen on this point.

It may be said, however (and this, perhaps, is the most prevailing notion), that little as the vulgar believed in the doctrine of a future state, it was received and inculcated by many eminent philosophers. But, in reality, the doctrine never was either generally admitted among the ancient philosophers, or satisfactorily proved by any of them, even in the opinion of those who argued in favour of it. On the one hand, not only the Epicurean school openly contended against it, but one of much greater weight than any of them, and the founder of a far more illustrious sect, Aristotle, without expressly combating the notion of a future state, does much more—he passes it by as not worth considering, and takes for granted the contrary supposition, as not needing proof. He remarks incidentally in his treatise on courage, that "death is formidable beyond most other evils, on account of its excluding hope; since it is a complete termination, and there does not appear to be *anything either of good or evil beyond it*." And in the same work, in discussing the question whether a man can justly be pronounced happy before the end of his life, he proceeds all along (as indeed is the case throughout), on the supposition, that after death a man ceases altogether to exist. And it should be observed, that his incidental and oblique allusion to this latter opinion, implies (as we have said) much more than if he had expressly asserted and maintained it. In *that* case he would have borne testimony only to his *own* belief; but as it is, we may collect from his mode of speaking, that such was the *prevailing* and generally uncontradicted belief of the rest of the world.

Of those philosophers, again, who contended for a future state, it is to be observed, not only that, as Dr Paley remarks, they did not, properly speaking, effect a *discovery;* " it was only one guess among many: he only discovers who proves;" but also, that (as has been said above) their arguments did not fully succeed in convincing even themselves. Those which at one time they bring forward as decisive proof, they seem, at another time, to regard as hardly possessing that degree of probability, which, now that the doctrine is established, most are ready to allow them. Cicero, especially, who is frequently appealed to on this question, we find distinctly acknowledging, at least in the person of one of his disputants, that though, while he is reading the Phaedo, he feels disposed to assent to the reasons urged in favour of a future state, his conviction vanishes as soon as he lays down the book, and revolves the matter in his own thoughts; which was the feeling probably with which the author himself had written it. Many, indeed, of the deistical writers of modern times have come to much more decisive conclusions on this, and also on many other points, than the ancients did, and, indeed, than are fairly warranted by any arguments which unassisted reason can supply; but this only affords a presumption of the powerful, though unacknowledged and perhaps unperceived influence which the Gospel revelation has exercised even on the minds of those who reject it. They have drunk at that stream of knowledge, which they cannot or will not trace to the real source from which it flows.

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[1] Epist., lib. ii., Ep. 20.

[2] Thus Catullus :—

> Soles occidere et redire possunt:
> *Nobis* cum semel occidit brevis lux,
> *Nox est perpetua una dormienda.*

[3] ὁι λοιποι, not as in our version, *others*.

As, however, even the faintest conjecture of a future existence, though it must not be confounded with a full assurance of it, is, as far as it goes, an approximation towards the knowledge of truth; so also, notions considerably incorrect respecting that existence, if they are but such as to involve the idea of enjoyment or suffering, corresponding with men's conduct in this life, have so far something of a just foundation, and of a tendency to practical utility. This, however, appears by no means to have been the case with the systems of any, as far as we can learn, of those ancient philosophers who contended the most strenuously for the immortality of the soul. For not only do they seem to have agreed, that no suffering could be expected by the wicked in another life, on the ground that the gods were incapable of anger, and therefore could not punish; but the very notion of the soul's immortality, as explained by them, involved the complete destruction of distinct *personal* existence. Their notion was, that is, when they spoke their real sentiments (for in their *exoteric* or popular works, they often inculcate, for the benefit of the vulgar, the doctrine of future retribution, which they elsewhere laugh at), that the soul of each man is a portion of that spirit which pervades the universe, to which it is reunited at death, and becomes again an undistinguishable part of the great Whole, just as the body is resolved into the general mass of matter. Sô that their immortality, or rather eternity, of the soul, was anterior as well as posterior; as it was to have no end, so it had no beginning; and the boasted continuance of existence, which, according to this system, we are to expect after death, consists in returning to the *state in which we were before birth;* which every one must perceive is the same thing virtually with annihilation.

Such, then, were the views which prevailed among the most enlightened nations of antiquity on this subject. On the other hand, the Hindoos of the present day do seem to believe in a future state of existence. They hold the doctrine of transmigration, *i. e.*, that the souls of all men (except those of extraordinary holiness) are doomed to migrate into the bodies of various brutes, and at length, if found worthy, are admitted into heaven.[1] And the kind of holiness which they expect will entitle men to future happiness, consists not in virtuous conduct, but in rich offerings, and the performance of various ceremonies, many of them excessively cruel; such as hanging themselves up by iron hooks plunged into their flesh, and other self-inflicted tortures. And a woman who burns herself alive along with her husband's corpse, and any one who drowns himself in the sacred river Ganges, or gives himself to be devoured by certain sacred alligators, or to be crushed under the wheels of the sacred car of the idol Juggernauth, is supposed to gain the special favour of their gods.

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[1] The heaven of the Buddhists, however, is manifestly annihilation circuitously described.

The real character, then, of the Pagan religions, being such as we have described, we are naturally led to wonder that the Israelites should so often have fallen into idolatry, after having had the true God revealed to them. Although He had so earnestly warned them not to worship any other gods, we find them continually joining the worship of Baal and other heathen gods with that of Jehovah. This appears to some persons so strange as to be hardly credible; and yet the very same thing is going on, almost before our eyes, in christian countries at this very day. For in all parts of Europe the most uneducated portion of the people in remote districts are found to believe in, and fear various superhuman Beings, which are in reality no other than the gods of their Pagan forefathers. And though they do not give them the title of *gods*, they often pay them great reverence, and make some kind of offerings to them.

In some parts of the British Islands, Fairies are believed in and venerated. In Scotland, besides these, we hear of Bogles, Brownies, and Kelpies, as names of certain superhuman Beings dreaded by the superstitious. In Denmark and Iceland, we hear of Trolls; in Germany of Nixes, and many other such Beings, who are supposed to have power in human affairs. In Norway, the country-people are said to make an offering of a cake once a year to a demon which they dread; and also of the first cheese that is made each spring. In some parts of our own country, a cottier's wife will not venture to bake bread or churn butter, without offering a portion to the fairies. And several other such acts of superstitious devotion are practised in various parts of Europe.

Now, there is every reason to believe that all these Beings who are thus reverenced, are, as we have already said, the very heathen gods which were formerly worshipped in each country. And the persons who shew them this reverence, and who seek their help, and dread to displease them, and aim at obtaining their good-will, are doing exactly the same as the Israelites of old, when they worshipped Baal, and Astaroth, and other gods of the heathen.

But what misleads people in their notions on this subject, is, that the *words* we use are not the same as the ancient Pagans used. What were formerly called by some name answering to " gods," are now called fairies, or " kelpies," or genii, &c., and the reverence shewn them is not called *worship*; and the offerings made to them are no longer called *sacrifices*. And thus it is that professed Christians deceive themselves by means of words, and fancy that they are not paying worship to any gods besides the Lord, though they are doing the same thing under other names.

With respect to the way in which false religions were first introduced, there can be no doubt that they must have crept in gradually. For men would not all at once forsake the worship of the Great Creator, and forget his very existence, and serve other gods *instead* of Him. But it is likely that, when they had come to imagine certain inferior spirits to reside in the sun and moon, the sea, rivers, groves, &c., they would next be led to call upon these Beings, in the hope that, *perhaps*, such prayers might be heard. And when once the practice has arisen of men's *adding on* to the worship of the Most High, some invocations of other inferior Beings, this latter kind of worship always tends to prevail over and drive out the other. Men seem to think that an inferior Being who approaches more nearly to their own nature, is more likely to feel sympathy with them, and perhaps is also more likely to be gratified by their adoration and their offerings, than the Supreme God. And even at this day there are some Pagan nations who are said to acknowledge the existence of a Great Being, who is the Supreme Ruler of all things, but whom they think it would be presumptuous for them to address; so that all their worship is reserved for some supposed gods of a lower order.

This at least is certain, that the Apostle Paul expressly informs us (Romans i.) that false worship did not first originate among men from their knowing nothing, and having no means of knowing anything, of the true God, and being left entirely to their own conjectures. For he distinctly declares, that some at least, " when they knew God, glorified him not as God," and " did not like to retain God in their knowledge, but changed the truth of God into a lie, and worshipped the creature more than the Creator."

It is very probable (and this seems to have been the Apostle's notion) that many of the more intelligent portion of mankind, in the days when false worship first arose, did not themselves partake of the superstitions of the weaker and more ignorant, but encouraged those superstitions for the sake of gratifying the vulgar, or keeping them in subjection to themselves, by means of a religion suited, as they thought, to unenlightened and feeble minds. Certain it is, that some dishonesty of this kind has often been practised in various ages and countries, and under various religious systems. Men of education and intelligence have often thought themselves justified in disguising, or concealing, or altering some portion of what they believed to be religious truth, and teaching or encouraging the vulgar to believe something different from what they themselves believed. And this dishonest system has always led, in the end, to the grossest corruptions, both of doctrine and of morals.

One great cause, probably, of the multiplication of gods among the Pagans, was the use of images or pictures. When men had introduced the practice of making some kind of emblem, intended to represent either the Supreme God, or any other Being they worshipped, they would easily be led to pay more and more veneration to the emblem itself, so as to become what is properly called " idolaters," that is, worshippers of an image or picture. And it would often happen that one set of men would venerate one image, and others another somewhat different, though originally designed to represent the same being. And there would also be some difference in the kind of worship paid to each of these images, and in the tales related concerning it; so that by degrees some of them would come to be considered as so many distinct gods.

Thus it seems to have been a matter of doubt whether there were not two Jupiters; whether there were one, or two, or three Mercuries; whether the Moon, and Diana, and Hecate, were three goddesses or one; and the like in many other instances. And, probably, this was one reason why the Israelites were so strictly charged, in the law of Moses, to worship, all of them at one place, " which the Lord should chuse to set his name there," lest, from having several different temples, that barbarian and gross-minded people should come to imagine there were several gods.

It often happened that different tribes of men worshipped either different gods, or the same under some different emblem, and with different ceremonies. And there is reason to believe that the confusion which is recorded as having occurred at Babel—afterwards called Babylon—and which caused the dispersion of mankind into various countries, was in reality a dispute among them as to their worship of some god or gods. This, at least, is certain, that the scheme mentioned in Gen. xi. was something displeasing to God, and therefore could not have been *merely* the building of a tower. And it is plain, also, from the Bible history, that some ages after the Flood mankind had very generally fallen into gross idolatry, though we are not told expressly when and how it was introduced.

As for the Tower of Babel, it is said indeed in our version that a number of persons joined together to build "a tower whose top should reach to heaven" (our translators meant an exceeding high tower), in order that they might not be " scattered over the face of the whole earth;" and that God sent on them a confusion of language, which caused them to "cease building the tower, and scattered them." But it is to be observed that the word " reach " is supplied by our translators, there being nothing answering to it in the Original, which merely says, " whose top to the heavens."

And the meaning doubtless is, that the top of the tower should be *dedicated* to the Heavens—that is, that a temple should be built on it to Bel, Belus, Zeus, or Jupiter; under which titles the ancient Pagans worshipped the heavens. For we find the historian Herodotus,[1] who many ages after visited Babylon, expressly declaring that there was there, in his time, a very high tower, on the top of which was a temple to Belus; who, he says, was the same with the Zeus of the Greeks.

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[1] Διὸς Βήλȣ ἱρὸν χαλκόπυλον, και ἐς ἐμὲ τȣ̃το ἔτι ἐὸν, δύο σταδίων, παντη, ἐὸν τετράγωνον·ἐν μέσωδὲ τȣ̃ ἱρȣ̃ πυργος στερεὸς οἰκοδόμηται, σταδίȣ και το μηκος και το εὖρος· και ἐπὶ τȣτω τω πυργω ἄλλος πυργος επιβεβηκε και ἕτερος μαλα ἐπὶ τόυτω, μεχρις ȣ̃ οκτω πύργων· * * * * * * Εν δε τω τελενταίῳ πυρ῾γω νηὸς επεστι μεγας.·—HERODOTUS, *Book* i., clxxxi.

The ancient Pagans, it is well known, were accustomed to erect altars to the Heavens, or to the Sun, on "high places" (Numb. xxxiii. 52), on the loftiest *mountains*. And as the land of Shinar is a very fertile *plain* of vast extent, and quite level, it seems to have been designed to make a sort of artificial mountain on it—that is, a very high tower—and to build a temple, on the top of this, to their god Belus, and so establish a great empire consisting of people worshipping at this temple.

The "confusion" which God sent among them, and which caused the tower to be less lofty than originally designed, and dispersed many of the people into other lands, was most likely not a confusion of *language*, but a dissension about *religious worship*. The word in the original literally signifies *lip*.[1] And it is more likely that it was used to signify *worship* than *language*. A dissension as to *that* which was the very object of the building, would much more effectually defeat the scheme than a confusion of languages. For, labourers engaged in any work, and speaking different languages, would in a few days, learn, by the help of signs, to understand one another sufficiently to enable them to go on with their work. But if they disagreed as to the very object proposed, this would effectually break up the community.

As for the different languages now spoken in the world, there is no need of explaining that by any miraculous interference. For, tribes who have not the use of letters, and have but little mutual intercourse, vary so much from each other in their language, after even a few generations, as not to be able at all to understand each other.

But while, as was remarked before, we have no express accounts of the first origin of the Pagan religions, this at least is certain, that it was not even pretended that these religions rested on any evidence worth listening to. A Pagan's reason for holding his religion is, and always was, that it had been handed down from his ancestors. They did indeed relate many miracles, said to have been wrought through their gods; but almost all of these they spoke of as having been wrought among people who were already worshippers of those gods, not as having been the means of originally bringing in the religion. And all the Pagan miracles were believed merely because these were a part of the religion which they had learned from their fathers. In a word, the religion did not rest on the miracles, but the miracles rested on the religion.

The christian religion was distinguished from these by its resting on evidence—by its offering a reason, and requiring Christians to be able to give a reason for believing it.

THE MOSAIC DISPENSATION.

It is plain from Scripture history, that both before the Flood and afterwards, God did, from time to time, hold communication in some way or other, with mankind—that is, with such as continued faithful worshippers of Him.

To Noah, in particular, we find Him giving commandments both before the Flood and immediately after it, and accepting sacrifice from him. In a later age we read of divine commands issued to Abraham, and promises made to him of peculiar blessings to a nation which should descend from him through Isaac; and also of an extension of blessings to all mankind through them—that "in his seed should all the nations of the earth be blessed." (Gen. xii., xxii.)

And although idolatry and gross wickedness seem, in Abraham's time, and afterwards, to have overspread most parts of the world, still there were some besides him and his family, who retained the worship of the true God. For, in the history of Abraham, we find mention of Melchizedek, a king, who held also the office of "a priest of the Most High God." (Gen. xiv.)

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[1] שְׂפַת χειλη (Septuagint).

Jethro, again, the father-in-law of Moses, appears to have been a worshipper of the true God; and the prophet Balaam, though a wicked man, is spoken of as a real prophet of the Lord.

It is probable, also, that some of the Egyptians were worshippers of the Lord, though so many of that nation had fallen into idolatry. For we read of Joseph's marrying the daughter of an Egyptian priest (Gen. xli.), and though possible, it does not seem likely, that so eminently pious a man would have married the daughter of an idolatrous priest. This, at least, is certain, that the historian Plutarch speaks of a certain portion of the land of Egypt which was exempted from the tax levied on the rest for the support of idolatrous worship. And this, he says, was on account of their being worshippers only of ONE, whom they called Cneph, "the unbegotten God."[1] And the plagues inflicted on Egypt by the Lord God of Israel,[2] the complete dominion He displayed over the Beings the idolaters worshipped, must, no doubt, have brought some of the Egyptians to acknowledge and worship Him. (Exod. ix.) But we are told very few particulars of the faith or the worship[3] of the servants of the true God, till we come to the time when Moses, by divine command, delivered to the "chosen" (elect) "people of Israel" that system of religion which is called "The LAW."

Of this—the Mosaic law—we find a full account in the last four Books of Moses. And these should be carefully studied by any one who would gain as accurate an understanding as possible of the system under which that most remarkable nation, the Israelites, were placed.

For our present purpose, it will be sufficient to mark out the most important points which *distinguished* the Mosaic Dispensation—the religion of the Israelites—from what came before it, and from what followed it; on the one hand, from the religion of those worshippers of the true God who lived *before* the time of Moses, and on the other hand, from the Gospel-Dispensation—the religious system under which *we* are placed.

The Law was designed to prepare the way for Christianity—a religion intended for all mankind—according to the promise made to Abraham, that some person or persons descended from him should prove a blessing to all nations. Yet the Law itself was given to *one* people alone. And accordingly, when the Apostles of Jesus Christ, who were themselves Jews, converted vast multitudes of Gentiles to Christianity, teaching them, among other things, to acknowledge the divine origin of the Mosaic Law, they yet taught them that the ordinances of that law did not extend to Gentiles.[4] (Gal. v.)

It is to be remembered, however, that before the Gospel revelation, a Gentile was allowed, if he wished it, to become a proselyte; and thenceforth he was not regarded as "unclean" (Acts x.), and an "alien" (Eph. ii. 11, 12), but only as ranking next below the Israelites by birth.

And, moreover, Gentiles who, though they had renounced idolatry, yet did not conform to the whole Law, but only to a certain small number of regulations, were admitted to worship in the outer court of the Temple ("the court of the Gentiles," 1 Kings viii. 41), and to attend divine service in the synagogues. These Gentiles are often alluded to in the Book of Acts (Acts x. 2; xiii. 16, 26, 43; xvi. 14; xvii. 4, 17), under the title of "the devout,"[5] or "they who feared God"[6] (that is, the Lord Jehovah), such as was Cornelius the centurion. And after the time of the Captivity, there were, in various countries, many Jews residing dispersed among the Gentiles;[7] and these Gentiles had thus an opportunity of learning (as a considerable number of them did learn) to know and to serve the true God. But those Gentiles who had no Jews resident among them had no such opportunity.

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[1] Αγέννητον ὄντα καὶ ἀθάνατον. They were the inhabitants of Thebais.—PLUTARCH, *De Iside et Osiride.*

[2] "On all the gods of Egypt will I execute judgment."—(Exod. xii. 12.)

[3] It is the opinion of many learned men that it was the practice of the servants of the true God, in the earliest times, to keep holy the last day of the week [Saturday] in memory of the close of the work of creation. And this seems probable, though no such practice is expressly recorded. But their *mode* of observing the day could hardly have been altogether the same with what was enjoined to the Israelites. To these the Sabbath seems to have been, in the *particulars* of the observance, a *new* and a *peculiar* institution. And accordingly we find, in the Prophecy of Ezekiel, the Lord saying, "I *gave them* [the Israelites] my Sabbaths, to be a *sign* between me and them."

[4] "Let no man judge you" (says the Apostle Paul, when writing to the Gentiles), "in meat or in drink, or in respect of an holyday, or of the new moon, or of the sabbath-days, which are a shadow of things to come; but the body is of Christ."—(Col. ii. 16.)

[5] οἱ σεβομένοι.

[6] οἱ φοβούμενοι τὸν Θεὸν.

[7] These are called "the Jews of the Dispersion" (see the beginning of the Epistle of James); or simply "the Dispersion."

Why it was that the Most High thought fit to make a revelation to this one people, and not at once to all the world, we cannot explain, and must not presume to decide. Indeed, we cannot explain why the Gospel was not preached to the very first generation of mankind; and why Jesus Christ came into the world just when He did; nor yet why many nations, in various parts of the world, have been left, even to this day, in the darkness of idolatrous superstition; or indeed, why any such thing as EVIL should exist at all.

All this, we must conclude, would have been explained to us in Scripture, if it had been necessary for us to understand it. As it is, any attempt to explain these things is fruitless and presumptuous. It is *our* business to inquire, not what *we* should have done, had the regulation of things been left to us, but what God has actually done, and what He requires us to do.

We have the most satisfactory reasons for believing that the Law of Moses was given by divine command; and also that it was given to the one nation of Israel, and not designed for the rest of mankind.

One of the many marks one may perceive of this design is, that it was a *local* religion. The Israelites were directed to offer sacrifices, and to worship three times a-year, at the one "place which the Lord should chuse to set his name there" (that is, to place there the manifestation of his presence and power); and they were strictly forbidden to sacrifice anywhere else. (Deut. xii. 13.) And, accordingly, when the Temple at Jerusalem had been finally fixed on as the chosen place, the destruction of that Temple made it thenceforth impossible for an Israelite to keep up the chief ordinances of his religion.

Hence the final destruction of that Temple abolished, manifestly and totally, the Mosaic system of religion.

And it is very remarkable that that religion is almost the only one that *could* have been abolished *against the will* of the people themselves, and while they resolved firmly to maintain it. *Their* religion, and theirs only, could be, and has been, thus abolished in spite of their firm attachment to it, on account of its being dependent on a particular *place*. The christian religion, or again, any of the Pagan religions, could not be abolished by any force of enemies, if the persons professing the religion were sincere and resolute in keeping to it. To destroy a christian place of worship, or to turn it into a Mohammedan mosque (as was done in many instances by the Turks), would not prevent the exercise of the christian religion. And even if Christianity were forbidden by law, and Christians persecuted (as has in times past been so frequently done), still they might assemble secretly in woods or caves, or they might fly to foreign countries to worship God, according to their own faith; and Christianity, though it might be driven out of one country, would still exist in others.

And the same may be said of the Pagan religions. If it happened that any temple of Jupiter, or Diana, or Woden, were destroyed, this would not hinder the worshippers of those gods from continuing to worship them as before, and from offering sacrifices to them elsewhere.

But it was not so with the Jews. Their religion was so framed as to make the observance of its ordinances impossible, when their Temple was finally destroyed. It seems to have been designed and contrived by divine providence, that as their law was to be brought to an end by the Gospel (for which it was a preparation), so, all men were to perceive that it did come to an end, notwithstanding the obstinate rejection of the Gospel by the greater part of the Jews. It was not left to be a question and a matter of *opinion*, whether the sacrifices instituted by Moses were to be continued or not; but things were so ordered as to put it out of man's power to continue them.

But, moreover, this local character of the religion shewed, from the very first, that it could not be designed for all mankind.

And the same thing is indicated by the way in which all the laws are expressed. For it is remarkable that even those duties which, from their very nature, must be duties for all men, such as to worship the one true God only, and to honour one's parents,—even these are enjoined to the Israelites in commandments which expressly refer to that one peculiar people. "I am the Lord thy God, who *brought thee out of the land of Egypt;* thou shall have none other gods but Me: and "Honour thy father and thy mother; that thy days may be long in *the land which the Lord thy God giveth thee,*"—that is, the land of Canaan.

Of course Christians are bound to practise these and all other moral duties. But that is because they are in themselves *moral* duties; not because they are enjoined in the Law of Moses; which was designed for the one people of Israel.

Other commandments there were, relating to matters originally indifferent, but respecting which God laid down certain rules; and required the Israelites to comply with those rules in submission to his will.

Some of these commandments related to religious ceremonies or observances, such as the keeping of the Feast of the Passover—coming up to the Temple at Jerusalem three times a-year—abstaining from certain meats, and wearing certain peculiar garments; with other things of that kind. These are commonly called *ceremonial* laws.

And, again, there were other commandments called *civil* laws; being such as relate to matters which the civil governors of any country have a right to regulate, from time to time, as they think best; and to enforce by penalties, such as imprisonment, banishment, or death.

For, the Lord was not only the *God*, but also the *King* (or civil governor) of this peculiar people; and enacted all such laws for their good government as the rulers of any other nation are authorised to enact and enforce, and to annul or alter whenever they see fit.

Of this kind was the law that no man should part with his landed property finally, but that, if sold, it should return to him, or his heirs, at the jubilee; and that which directed that a man should marry his brother's widow if his brother died childless (Deut. xxv. 5, and Luke xx. 29), with many other such laws.

Now, the ceremonial and the civil laws being such as relate to matters in themselves indifferent, are what are commonly called "*positive* precepts:" those relating to points of natural duty being called "moral precepts." And it is very important to keep in mind the distinction between these two classes of laws. Any thing enjoined by a *positive* precept is *right because it is commanded*: any thing *enjoined* by a moral precept is *commanded because it is right.*

Thus it was, to the Israelites, a duty to keep the Passover, as it is to Christians to celebrate the Lord's Supper; *because* divine commands to do so were given, and it is a moral duty to obey divine commands. But there was no such duty *before* those express commands were given.

On the other hand, to honour one's parents is, from the nature of the case, a duty of all men; and the Israelites were commanded to do so, because it is right in itself.

Again, to abstain from all worship of false gods, or of images, and to reverence the true God, is a *natural duty*, and was enjoined to the Israelites because it is so. But no one would say that it is a natural duty to keep holy one day in seven, rather than one in six, or in eight; or to keep holy the last day of the week, rather than the first, or any other; or to abstain from kindling a fire (Exod. xxxv. 3) on that day. But all this became a duty to the Israelites when they had received a divine command to observe in that particular manner that particular day; and so with other commandments.

Again, the Mosaic Law was distinguished from every other revelation ever bestowed on man, by the great number and minuteness of its regulations, and the multitude of its ceremonial observances. It gives exact directions to the Israelites as to their diet, their dress, and their mode of life in many particulars.

One purpose answered by these numerous ordinances, was to keep them quite distinct from other nations; that they might be the better preserved from falling into the idolatrous worship of their neighbours, and might be marked out, both to them and to themselves, as the Lord's peculiar people.

And moreover, it was needful for a half-barbarian and gross-minded people, such as the ancient Israelites, to keep up in their minds the thought of their religion, by a great number of outward ceremonies and observances. These served to remind an Israelite continually of the God whose servant he was, by his being required from day to day to observe certain rules, and to perform certain acts, as a sign of his obedience to the Lord, and as a part of his religious duty.

And a great part of the ceremonies of this law had also a *typical* meaning. In particular, the Passover, and all the other sacrifices of animals, were types representing the sacrifice of Christ on the cross for man's redemption. And, accordingly, we find the Apostle Paul expressly calling Him "our Passover, who is sacrificed for us." (1 Cor. v. 7.) For as the blood of the first paschal-lamb sprinkled on the door-posts of the Israelites in Egypt (Exod. xii. 7) was to preserve their first-born from the destroying angel which slew the Egyptians, so the sacrifice of Jesus Christ brings eternal deliverance and salvation to those who will be truly his disciples. And He is thence called in Scripture, "The Lamb of God, who taketh away the sin of the world."

And throughout the New Testament, there are numerous references to the sacrifices and other ceremonial ordinances of the law, as types representing the redemption by Christ, and foreshewing the Gospel dispensation.

But all this was not understood, nor designed to be understood, by the Israelites to whom Moses delivered the Law. They were only required to observe strictly and carefully the directions given, without understanding the full meaning of all that was ordained. The Law of Moses, therefore, was like some important document written in *cypher*, or in an unknown language; which a man is directed to preserve very carefully till such time as he shall be furnished with a key to the cypher, or a translation. Just so, the Gospel, when it was revealed, furnished an interpretation of many things in the Mosaic Law, which had been before unintelligible as to their inward meaning.

And this is what the Apostles mean when they speak of "*making known* the *mystery* of the Gospel." For "mystery" signifies, in *their* use of the word, something that *has* been concealed, and is afterwards *revealed* and explained. (Eph. vi. 19.)

Another distinguishing character of the Mosaic Law was, that it was enforced by a system of *temporal rewards and judgments*, administered according to an *extraordinary providence.*

The Israelites were promised, as the reward of obedience, long life, and health, and plentiful harvests, and victory over their enemies. And the punishments threatened for disobedience, were pestilence, famine, defeat, and all kinds of temporal calamity. (Deut. xxviii.)

And the history of this most remarkable people is full of examples of the fulfilment of these promises and threats.

In the Books of Moses himself, and the historical books that follow, we find abundant instances of both kinds recorded. The Lord (Jehovah) was, as has been remarked above, not only the God, but also the *King* (or civil governor) of this peculiar people. And hence the word "Theocracy" is often applied to the system under which the Israelites lived. Hence, too, it was, that among them the worship of other gods was made a *capital crime;* because, under such a system, it amounted, in fact, to *high treason.* (Deut. xvii. 2.) For, it is to be remembered, that the Pagans regarded *their* gods as their temporal rulers; looking to them for victory and success of all kinds, consulting them, and acting on their supposed directions. The ideas of *tutelar* god, and *king*, were so blended in the minds both of the Pagans and the Israelites, that an Israelite could not worship Baal or Moloch, without so far withdrawing his allegiance from Jehovah his King. And even when they were ruled by judges, or by kings, they were under this theocracy; these rulers being considered as merely agents or deputies of the Lord their King, and appointed or removed by Him. He issued direct commands, from time to time, to the nation, or their governors, as to various temporal concerns, such as are regulated by the supreme rulers of each State. (1 Sam. xv.)

And as all rulers enforce their commands by temporal penalties on the disobedient, such as forfeiture of goods, bodily chastisement, or death, so the Lord enforced on the Israelites obedience to his commands by temporal rewards and punishments, distributed according to an extraordinary providence.

It appears to have been designed in that dispensation to exhibit to mankind a sensible specimen, or rather *representation*, by way of proof, of that moral government of God, the system of which is but imperfectly displayed in the world at large; and which is to be completed, and fully realised, only in a future state.

It would be inconsistent with the present occasion to enter into a full explanation and defence of this hypothesis: let it be allowed, however, to adopt for the present, the supposition, merely *as* a *supposition*, that the Mosaic dispensation was, in part, designed for the purpose just mentioned; that we may examine how far the peculiar circumstances of that dispensation correspond with and are explained by it. It would manifestly be necessary, then, with a view to the object in question, that the Israelites should be exhibited as *uniformly and regularly* rewarded or punished, according to their obedience or disobedience to the divine commands. And moreover, in order that the correspondence of their situation with their conduct might be more *conspicuously* displayed, it was necessary that they should be *nationally* as well as individually, prosperous or unfortunate, in consequence of their good or ill conduct; since the fate of individuals would have been too *obscure* to engage general attention. It was requisite, for the same reason, that the obedience required of them should not consist in *moral rectitude* alone; because in that case the correspondence of their circumstances to their behaviour would not have been sufficiently *manifest.* For moral virtue consists, chiefly, in purity of motives, and propriety of inward feelings; concerning which other men cannot with any certainty form a judgment. It was requisite, therefore, that their obedience should be tried in the practice of *external* rites, and in a conformity to certain *positive ordinances.* For these observances, though originally matters of indifference, yet, as we have before observed, assume a moral character, and become duties, when enjoined by divine authority; and the obedience or disobedience of a people on such points, is a matter open to general observation, and on which no one would be liable to mistake.

Lastly, with the same view, it was no less requisite that the *rewards and punishments* also, which should be the sanction of such a law, should be of a nature no less palpable and open to general observation; and should therefore not consist in anything inward and invisible, as in peace of mind, and in horrors of conscience; nor in the hopes and fears of a future state; but in the immediate and conspicuous distribution of outward worldly prosperity and adversity.

The close correspondence, in all points, of the dispensation actually given, with the foregoing description, is no slight presumption that the object of that dispensation was, in part at least, such as we have supposed,—viz., to exhibit to mankind, (that is, to those who should be in early times neighbours to the Israelites, or have any intercourse with them, and subsequently to us, and to all others who should read their history, and view their present fate); to exhibit, we say, a striking picture of God's moral government,—to convince all men of his superintending providence,—and to instruct them in the principles of justice, by which his dealings with them will be regulated.

We must, however, carefully keep in mind the distinction between an extraordinary providence, such as that under which the Israelites were placed, and the ordinary divine providence by which the world generally is governed, and which is sometimes called the "course of Nature."

God has appointed that, as a general rule, though not an invariable one, good conduct shall lead, on the whole, to temporal success and welfare, and ill conduct to misfortunes of various kinds. Thus, the *general* tendency of industry and frugality is to lead to prosperity; and of idleness, improvidence, and extravagance, to poverty and distress. Temperance conduces, on the whole, to health, and intemperance usually brings on disease and death. The quarrelsome, the hard-hearted, and the unjust, are likely to be hated or despised; while gentleness and kindness tend, in general, to procure a man the good-will of his neighbours; and (according to the proverb) in the long run, "honesty is the best policy."

Accordingly, in the ordinary course of events, we are generally able to *trace* men's good or ill success in life, to their good or ill conduct. For instance, when a man who has lived a life of sensuality and extravagance is ruined in health and in fortune, we can perceive the connection between his misery and the vice and folly that have *naturally* caused it. Or again, if an honest, industrious, and prudent man becomes rich, we say that this is according to the *natural* course of things. And so in other such cases. We do not mean, when we speak thus, that the "natural course of things" is *not* regulated by divine providence, but merely that such is the *ordinary*, established, and regular course of God's government of the universe.

On the other hand, when any occurrence is spoken of as "supernatural" (or "miraculous"), although the word "providential" is sometimes applied in the same sense, any one who believes that God is the supreme disposer of *all* events, cannot mean that such an occurrence is *more providential* than others, but merely that it belongs to God's *extraordinary* providence.

And in any such case we can trace no connection between the sin and the punishment, or between the good conduct and the reward, except so far as we learn it from *express revelation.* For instance, when Korah (Numb. xvi.) and his company were swallowed up by an earthquake, as a punishment for having "provoked the Lord," we know that this was a judgment on them for that sin, solely because Moses, by divine command, expressly declared the sin, and *foretold* the punishment.

And again, when the Israelites were defeated before Ai, as a judgment for the transgression of one of them (Josh. vii.), and when the land of the ten tribes was burnt up with drought, in the days of Ahab, as a punishment for their idolatry (1 Kings xvii.), we can trace no *natural* connection between the sin and the consequences of it; and we know this connection only because we are expressly told it in Holy Scripture.

Would it not, then, be in the highest degree presumptuous for any one of us, uninspired men, to pronounce judgment on those who are cut off by sudden death, or who are visited by such calamities as an earthquake, a famine, or a pestilence? Shall we take upon ourselves to declare the counsels of the Most High, when He has *not* revealed them? and, in defiance of our Master's express warning, proclaim that these men *were* sinners above those who have escaped such a fate?

And yet some persons do occasionally presume, without any commission from Heaven, to pass judgment on their neighbours, and to declare that such and such a calamity is a mark of divine displeasure, and a punishment for such and such a sin.

Such men are like the false prophets of old—their language is, "Thus saith the Lord, when the Lord hath not spoken." Whatever high pretensions they may make, it is not piety, but daring *im*piety, thus to mimic the voice of God's inspired messengers, and to come forward, without any divine commission, setting forth their own fancies as revelations from Heaven. It is not wisdom from above, but gross ignorance of *both* the volumes which the same divine Author has opened for our instruction—the volume of *Nature*, and the volume of *Revelation*,—that leads men thus to confound the ordinary and the extraordinary dispensations of his Providence. *Some* design, no doubt, the Allwise Governor of the world must have, in all his dispensations, whether of sorrow or of joy. He sends want, and He sends abundance,—He allots affliction, and temporal deliverance and prosperity, not at random, but according to some fitness which He perceives in the respective parties, to be the recipients of these dispensations.

The hardships undergone by the Apostles, they were exposed to, we may be assured, for some good reason; and so also, health, plenty, and every kind of temporal success, are doubtless bestowed with some wise design on those who obtain such advantages. But when He has not thought fit to reveal *what* his designs are, it is not for us, shortsighted mortals, to pronounce upon them, and presumptuously to usurp the office of his prophets. "Wherefore judge nothing," says the Apostle, "before the time, until the Lord come, who will bring to light the hidden things of darkness, and will make manifest the counsels of the hearts! and *then* shall every man have [his] praise[1] of God."

The notion, however, that calamity is *necessarily* a token of the divine displeasure, was one which the Jews very much clung to—and very naturally; inasmuch as that particular nation *had* been originally placed under such a system of temporal rewards and punishments. They found it hard to believe, therefore, in the change of that system, when the Gospel was preached. And accordingly, the sufferings and death undergone by Jesus and many of his disciples, formed the chief stumbling-block to the Jews (1 Cor. i. 23), most of whom would not believe that He could be the true Christ, or a favoured servant of God; because they regarded His *sufferings* as a proof of the divine *dis*favour.

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[1] ὁ ἔπαινος: viz., whatever he is justly entitled to. The Greek article has the force of our pronoun.

And their objection to Him, on this very ground, was accordingly foretold by the Prophet Isaiah (Isa. liii.): "a man of sorrows and acquainted with grief; and we hid, as it were, our faces from Him:" "we did esteem Him stricken, *smitten of God* and afflicted," &c. &c.

It seems strange to us that so many of the Jews should refuse to be convinced by such prophecies as this. But it is much more strange that there should be some Christians, who, though professed followers of a Master who was crucified, still persist in regarding temporal calamities as a proof of the divine displeasure against those who are so visited; and that there should be Christians who presume, against their great Master's express prohibition, to declare what the sins are that have called down on their neighbours such calamities.

Some persons, however there are, who carelessly use the words "providential" and "miraculous," merely to denote any thing *unusual* and strange. They talk of a "miraculous" escape from some danger, meaning merely a *wonderful* escape; and of a man's being delivered "providentially," when they mean only that the deliverance was striking and *remarkable.*[1] But it is best to abstain from this loose kind of language, lest we should be understood to mean either that other events are *not* providential, and that God's government does not extend to the ordinary course of things; or else, that we—uninspired men—are permitted to decide (in cases where there is no evident miracle) what are the designs of the Most High, and what are the occurrences that do, and that do not, belong to his extraordinary dispensations.

The nation of Israel was, as we have said, placed under an extraordinary providence, which allotted to them victory or defeat,—plenty or famine,—and other temporal blessings and punishments, according to their conduct. And these were the rewards and punishments that formed the sanction of the Mosaic Law. As for a future state of retribution in another world, Moses said nothing to the Israelites about that. Whatever may at any time have been revealed to himself, and to some other highly favoured individuals, on that subject, it does not appear that he was commissioned to deliver to the people any revelation at all concerning a future state. This was reserved for a GREATER than Moses, and for a more glorious dispensation than his Law. For as we read in the Epistle to the Hebrews "the law *made nothing perfect;* but the *bringing in of a better hope* did" (Heb. x.)—namely, the promises given through "Jesus Christ, who brought life and immortality to light, *through the Gospel.*"

Why Moses was not instructed to reveal this momentous truth, is a question which will naturally occur to every one. It is a question which we are not competent completely to answer; because, as has been elsewhere observed, we cannot presume to explain why the Gospel was reserved for that precise period at which it was proclaimed. But *that* inquiry,—why a different and more imperfect dispensation was needful to prepare the way for the Gospel,—being waived, as one surpassing man's knowledge and powers, it is easy to perceive that the revelation of the doctrine in the Mosaic Law would have been neither necessary nor proper. It was not necessary for the purpose of affording a sanction to the Law of Moses, because the Israelites alone, of all the nations of the world, were, as we have seen, under an extraordinary providence.

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[1] The reason some give for *distinguishing* some particular events as "providential," is in truth a reason on the opposite side. An unexpected recovery from a disease which seemed hopeless, or a wonderful escape from a shipwreck, &c., is, they say, more *striking* to their minds, and impresses them more with a sense of the goodness of Providence than ordinary occurrences.

Now, for this very reason, they should labour the more carefully to bring themselves to reflect on the *daily* benefits they receive from "Him in whom we live and move and have our being." The more prone we are to pass by with careless indifference our being preserved from *falling into* a dangerous sickness, or from *being* shipwrecked at all, the more we should study to bring our minds to dwell on such preservation; which is, in truth, *no less "providential"* than a man's being delivered *out of* a sickness or a shipwreck.

The necessary foundation, therefore, of all religion, "that God is a *rewarder* of them that diligently seek him," did not require, as it must in all other nations, the belief in a future retribution, to remedy all the irregularities of God's ordinary providence, which among this peculiar people did not exist, at least in the same degree and form, as among all others. Nor, again, would it have been proper for Moses, commissioned as he was to promulgate, not the Gospel, but the Law, to proclaim *that* life and immortality which the Gospel was destined to "bring to light;" much less, to represent eternal happiness as attainable *otherwise* than through the redemption by Christ, which the Gospel holds out as the only efficacious means of procuring it.

And accordingly it is observable that the slight hints of this doctrine which the books of the prophets contain—the faint dawnings, as it were, of a scheme which was to bring "life and immortality to light," and which appear more and more bright as they approached the period of that more perfect revelation, are in perfect consistency with the rule we have supposed Moses to have observed; since it is in proportion as they give more and more clear notices of the Redeemer to come, and in almost constant conjunction with their descriptions of his mission, that the immortal life, to which He was to open the road and lead the way, is alluded to by the prophets; and also in proportion as the *extraordinary* and regular administration of divine government in this world, by which the Law had been originally sanctioned, and under which the Jews had hitherto lived, was gradually withdrawn. That it was in these writings, and not in those of Moses, that the Jews must have sought for indications of a future state, is strongly confirmed by the opinion of that celebrated and learned divine, Joseph Mede, who declares that he cannot tell on what Scripture authority the Jewish Church could have founded their belief in a future state, except the well-known passage in Daniel; and even of that, it may be observed, that it does not necessarily imply a resurrection of *all* men. Doubtless it did not escape Mede that there are in the other prophets many allusions to a future state, which were so understood by the inspired authors themselves, as they are by us *Christian* readers; but it does not follow that the great mass of the people—any besides the studious and discerning few—would be able clearly to perceive such meaning, especially when a different interpretation of those very passages applicable to temporal deliverances, might, without destroying their sense, be adopted. Nothing appears to us more evident than the description in Isaiah, for instance, of a *suffering* Messiah; yet we well know that a prosperous and triumphant temporal prince was generally expected by the Jews, and that the frustration of this hope was the grand stumbling-block of the unbelieving among them.

So also many passages of the prophets, which convey to Christians, who have enjoyed the Gospel revelation, the intimation of a future state, (at least in their secondary sense), might very easily be otherwise understood; or, at least, might appear not decisive, to those who lived before Jesus Christ had "*abolished death*, and brought life and immortality to light through the Gospel."

We are told, indeed, that even at a time long antecedent to that of Moses, Abraham "eagerly desired[1] to see the day of the Lord Jesus; and he saw it, and was glad." In these words our Saviour is doubtless alluding to the sacrifice of Isaac, and to Abraham's being instructed on that occasion, that the transaction was a "*figure*" (Heb. xi. 19); representing the death and resurrection of Christ. But our Lord could not have meant that the revelation then made to Abraham was imparted by Moses to the whole nation of Israel.

It is highly probable, that both Moses himself, and Abraham, and other eminent and highly favoured servants of God in those days, received, more or less, revelations of several things which they were not commissioned to impart to all the people.[2] And among other things, it is likely they were taught something concerning the resurrection, and concerning Him who was to procure it. And accordingly we find the very same Apostle who speaks of the Gospel as "bringing in a better hope" than was in the *Law*, speaking also of some of the Patriarchs as "looking for a better country, that is, a heavenly." (Heb. xi. 16.)

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[1] This is the exact sense of the original, ἠγαλλιάσατο, John viii. 56; though our version renders it "rejoiced;" but Abraham's *joy* is what is mentioned afterwards.

[2] The eminently pious king, Hezekiah, however, seems to have had no idea, at least at the time when he composed his hymn, (2 Kings xx.), of any future state.

But when we look to what Moses wrote, by divine command, for *the instruction and guidance of the Israelites,* and as belonging to the Law—the dispensation committed to him—we find him dwelling very fully, and minutely, and earnestly, on the temporal rewards and temporal punishments they were to look for; saying nothing at all about a resurrection and a day of judgment in the next world.

Many persons however are accustomed, in speaking of the present subject, to confound together two very different questions: (1.) What was the actual belief of the Jews—or of some particular Jews—on this or that point? and, (2.) What was *revealed* to them in the LAW? No unprejudiced reader of that, can think that Moses designed to teach, therein, the doctrine of a future state of rewards and punishments as the sanction of his Law.

On the actual belief, indeed, of the great mass of the Israelites, we have no means of deciding positively; but if any one should suppose most of them to have thought little or nothing, one way or the other, about what should become of them after death, nor, consequently, to have either believed or disbelieved, properly speaking, the doctrine in question, his conjecture certainly would not be at variance with the representations Moses gives of the grossness of ideas, and puerile shortsightedness of the nation; who, while fed by a daily miracle, and promised the especial favour of the Maker of the universe, had their minds set on "the flesh-pots of Egypt, and the fish, and the cucumbers, and the leeks." Christians of these days are not surely *more* gross-minded and unthinking than those Israelites; yet a large proportion of *them* require to be incessantly reminded that this life is not the whole of their existence; though the doctrine be one which is expressly declared in their religion; and silence on that subject is quite sufficient, if not to eradicate from their minds all *belief*, at least to put an end to all *thought*, about the matter.

There is no doubt, however, that some considerable time before our Lord's advent, the belief in a future state did become prevalent (though, as the case of the Sadducees proves, not *universal*) among the Jews. In the Second Book of Maccabees, a work of small authority, indeed, as a history, but affording sufficient evidence of the opinions of the writer and his contemporaries, we find not only unequivocal mention of the doctrine, (though by the way not as an *undisputed* point), but persons represented as *actuated by the motives* which such a doctrine naturally suggests; which doubtless we should, sometimes at least, have met with also in the historical books of the Old Testament, had the same belief prevailed all along.

And our Lord himself alludes to the prevailing opinion of the generality of those whom he addresses: "Search" (or Ye search[1]) "the Scriptures, for in them *ye think* ye have eternal life, and they are they that testify of me;" as much as to say, the very prophets who allude to the doctrine of eternal life, do likewise foretell the coming and describe the character of me, the Bestower of it; these two parts of their inspired word hang together; he who is blind to the one, can found no *rational* hope on the other; since "I am the way, and the truth, and the life;" and "he that hath the Son hath life, and he that hath not the Son, hath not life." This passage, indeed, as well as the others to the same purpose in the New Testament, though they imply the prevalence of this tenet among the Jews, and the general *sincerity* and *strength* of their conviction, do not at all imply either that this, their confident expectation, was *well-founded* on Scriptural evidence, or that their notions respecting a future life were *correct*. Had these last two circumstances been superadded (which is evidently impossible) to the general sincere reception of the doctrine, it could not have been said with any propriety, that "Christ *brought life and immortality to light* through the Gospel."

The truth probably is, that as the indications of a future state which are to be found in the prophets, are mostly such as will admit of an interpretation referring them to a promise of temporal deliverance, those persons would most naturally so understand them, in the first instance at least, who were so "slow of heart" as to the prophecies respecting the Messiah, as to expect in Him a glorious *temporal* prince only; while those who were more intelligent, and took in the spiritual sense of the prophecies relating to *Him*, would be led to put the spiritual interpretation on the other also. We say in the *first instance;* because when the belief of a future state had been introduced, from whatever quarter, and did prevail, all who held it would naturally interpret in that sense whatever passages in their Scriptures seemed to confirm it. But it does not follow that such a belief was correct, even when supported by an appeal to passages of Scripture which really do relate to the doctrine in question; for if one part of a scheme be understood literally and carnally, and another part spiritually, the result will be a most erroneous compound; if eternal life be understood to be promised, but the character and kingdom of Christ, who was to bring it to light and procure it, be misunderstood, the faith thus formed will be essentially incorrect.

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[1] The word in the original, ἐρευνᾶτε, may bear either an imperative or an indicative sense.

So far, then, as any of the Jews disjoined the prophetic annunciations of immortality from those relating to the spiritual kingdom of Christ, and looked for eternal rewards as earned by obedience to the Mosaic Law, so far their expectations were groundless, their faith erroneous; even though resting on the authority of such parts of Scripture as, in a different sense, do relate to the doctrine in question.

It is highly probable, however, that the belief of a future state, as it prevailed among the Jews in our Lord's time, and for a considerable period after, was not, properly speaking, *drawn* from their Scriptures, in the first instance;—was not *founded* on the few faint hints to be met with in their prophets, though these were afterwards called in to *support* it; but was the gradual result of a combination of other causes with these imperfect revelations. For otherwise, one would expect that there would have been some notice in the Books of Ezra and Nehemiah (written after all the most important prophecies had been delivered) of so mighty a revolution having taken place in the minds of the Jews of their time, as a change from ignorance to a full conviction, on so momentous a point, by a supposed decisive revelation.

Respecting the details of the rise and prevalence of the doctrine of a future state among the great majority of the Jews, the scantiness of historical authority leaves us chiefly to our own conjectures. Without entering at large into a disquisition which must, after all, be obscured by much uncertainty, it may be allowable to suggest, that the Jews were likely to be much influenced by the *probable* arguments which their own reason partly supplied, and which they partly learned from the neighbouring nations, with whom (and with some of the more intelligent and enlightened of them) they had much more, and much more extensive, intercourse after the captivity than before. Nor does such a supposition militate, as might at first sight be suspected, against what has been elsewhere advanced respecting the prevailing disbelief, among the heathen, of the popular fables of Elysium and Tartarus, and respecting the emptiness of the pretended immortality of the soul, held by philosophers. For whatever their belief might be, they would be likely, in any discussion with their Jewish neighbours, to set forth either such arguments as occurred to them in favour of a future retribution, which undoubtedly was a part of the religion they professed, or such pretended proofs of the natural and necessary immortality of the soul, as their schools supplied. And such discussions we cannot but suppose must have been frequent; since the intercourse of the dispersed Jews with the Gentiles was such as to lead to the disuse of their own language, and the consequent necessity of a translation of their Scriptures into Greek. Now the Jews, who claimed to be favoured with an authentic revelation of God's will, and to be his peculiar People, could not have been satisfied to rest their pretensions to such superiority, and their boast of its advantages, on the extraordinary providence under which their *ancestors* had lived, but which seems to have been nearly, if not entirely, withdrawn from themselves; but would be likely to set up a rival claim to that of the Pagan religions, and to produce from their Scriptures every thing that might seem to favour the hope of a future reward. And this, not insincerely; for the very circumstance of the withdrawing of that miraculous providence under which their nation had formerly lived, would lead them to the expectation of something beyond the grave to compensate the loss. God's moral government of *their* nation, at least, they were assured of from their own past history; and if He had formerly been "a rewarder of them that diligently seek Him," they would perceive an improbability of his ceasing to be so; though in *this* world the "just recompense of reward" was evidently no longer to be looked for. It was to be expected, therefore, that they should be more inclined to believe sincerely in a future retribution than the Pagans, who had not the same experimental assurance that the Deity is indeed the moral Governor and Judge of mankind.

Some, however, make a careless use of those common words "know" and "believe." When discussing questions as to what was "believed" by such and such persons, they sometimes speak as if there were but these two states of mind,—to believe a certain doctrine, or to disbelieve it; forgetting, apparently, that belief admits of many different *degrees*, from a mere presumption, up to the most perfect confidence. Yet every one's own experience might teach him this. For we commonly say, "I *believe* so and so is the case, but I am not *quite sure*." Some, again, when they speak of what was "known" to the Pagans, or to the Jews, seem to forget that the word "knowledge" implies three things;—(1.) *Confident belief;* (2.) of what is *true;* (3.) on sufficient *evidence.* For no one could be said to *know* any thing that was not true. And again, if any one had before him one of Euclid's demonstrations, he would not be said to *know* the conclusion, (though a truth in reality fully proved) if he himself felt at all *doubtful* about it. And lastly, suppose two persons were quite positive, the one that the moon is inhabited, and the other that it is uninhabited, neither would be said to know the truth of his opinion; because, though one or the other must be, in fact, true, there is no sufficient *proof* of either.

It would be unsuitable to our present purpose—even if space admitted—to examine all the passages in the Books of Moses which have been interpreted as relating to a future state; it may be needful, however, to say a few words respecting that one which is cited by our Lord himself against the Sadducees, in proof of the doctrine: "Now, that the dead are raised," says He, "even Moses shewed at the bush, when he saith, 'I am the God of Abraham, and the God of Isaac, and the God of Jacob; He is not the God of the dead, but of the living; for all live unto Him.'" (Luke xx. 37.)

Now this passage is sometimes misunderstood, though the meaning of Jesus is sufficiently plain to an attentive reader of common intelligence. There was a dispute between two parties, whether there were or were not to be a resurrection. They had both of them heard of the doctrine, and had been accustomed to debate the question. And He refers them to a passage which, *to men so circumstanced*, would afford an argument in favour of the doctrine. But Jesus does not say that Moses designed in this passage to *reveal* the doctrine to the unreflecting and gross-minded people he was instructing; or that for *that* purpose those words were sufficient. No man of common sense—much less an inspired lawgiver, such as Moses—would have entrusted so important a revelation to one, slight, obscure, and incidental hint—so slight that the passage seems to have quite escaped the notice of the Pharisees when disputing with the Sadducees on this very point.

Had Moses been commissioned to teach the Israelites that they were all to rise from the dead, and to stand before God's judgment-seat, and be rewarded or punished in another world, according as they had obeyed or disobeyed the Law he was delivering, he would not, we may be sure, have thought it sufficient for this purpose, to record the words, "I am the God of Abraham, Isaac, and Jacob." He would, doubtless, have dwelt on the rewards and punishments of a future state even *more* copiously and more strongly than he does on the temporal rewards and punishments which he does set before them.

For, let it be considered, that as the condition of the departed is *unseen*, and as the rewards and punishments of a future life are not only comparatively *remote*, but also must be considered as of a nature very *different* from any thing we can have experienced; from all these causes, it is found necessary that the most repeated assurances and admonitions should be employed, even towards those who have received the doctrine on the most satisfactory authority. A Christian minister, accordingly, in these days, finds that his hearers require to be perpetually reminded of this truth, to which they have long since given their assent; and that even, with all the pains he takes to inculcate it, in every different mode, he is still but very partially successful in drawing off men's attention from the things of this world, and fixing it on the "*unseen* things that are eternal." Much more must this have been the case with the Israelites whom Moses was addressing, who were so dull and gross-minded, so childishly shortsighted and sensual, that even the immediate miraculous presence of God among them, of whose judgments and deliverances they had been eye-witnesses, was insufficient to keep them steady in their allegiance to Him. Even the temporal sanctions of the Law,—the plenty and famine—the victory and defeat, and all the other points of that alternative of worldly prosperity and adversity which was set before them —things in their nature so much more easily comprehended by an unthinking and barbarous people, and so much more suited to their tastes—it was found necessary to detail with the utmost minuteness, and to repeat and remind them of in the most impressive manner, in a vast number of different passages. (See Exod. xv. 26; xx. 12; xxiii. 20;—Lev. xxv. 17; xxvi. 3;—Numb. xiv. 20; xxxii. 10; xxxiii. 55;—Deut. i. 35; iv. 1; v. 29; vi. 2; vii. 12; viii. 1; xi. 8; xv. 4; xvi. 20; xvii. 19; xxviii. 1; xxix. 22; xxx. 1; xxxi. 16; xxxii. 23–43.)

Is not, then, the conclusion inevitable, that if to such a people the doctrine of future retribution had been to be revealed, or any traditional knowledge of it confirmed, we should have found it still more explicitly stated, and still more frequently repeated? And when, instead of anything like this, we have set before us a few scattered texts, which, it is contended, allude to or imply this doctrine, can it be necessary even to examine whether they are rightly so interpreted? Surely it is a sufficient reply to say, that if Moses had intended to inculcate such a doctrine, he would have clearly stated and dwelt on it in almost every page. Nor is it easy to conceive, how any man of even ordinary intelligence, and not blinded by devoted attachment to an hypothesis, can attentively peruse the Books of the Law, abounding as they do with such copious descriptions of the temporal rewards and punishments (in their own nature so palpable), which sanctioned that Law, and with such earnest admonitions grounded on that sanction, and yet can bring himself seriously to believe, that the doctrine of a state of retribution after death (which, it cannot be contended, is even mentioned, however slightly, in more than a very few passages) formed a part of the Mosaic revelation.

It deserves to be remarked here how strong an internal evidence of the truth of what Moses wrote, is afforded by the fact, that he thus represented the sanction of his Law as consisting of temporal rewards and punishments only.

For had he been a false pretender, he would have known that he could not secure the constant *fulfilment* of his promises and threats. And his imposture would have been detected, when men found that they were not regularly rewarded and punished according as they obeyed or disobeyed his law. We may be sure, therefore, that a crafty impostor would not have trusted entirely to promises and threats of temporal goods and evils alone. He would, doubtless, have taught the Israelites to look for a state of future retribution also; which was done by the ancient heathen lawgivers. Most of these, probably, did not themselves believe in what they taught about Elysium and Tartarus; but they judged it wise to try to make their people believe it, for the sake of keeping them in awe. And they knew that the falsity of their promises and threats respecting *another world* could not be detected by *experience.*

And Moses, no doubt, would have proceeded in the same manner, had he been a pretender. But he was fully convinced that the Israelites really did live under that miraculous Providence which he described. And their own experience taught them that what he said was true. (Deut. iv. 3, 4.)

As for the particulars of all the various instructions given to the Israelites, both by Moses and by the other writers of what is called the Old Testament, these are to be learned only from a careful study of those books themselves. Our present design was merely to give a sketch of the general character of what is called the Mosaic Dispensation, especially as to the points wherein, it differs from other religious systems.

It is to be borne in mind, then—1*st*, That it was designed for one People alone, though it was preparatory to a religion intended for all the world; and its ordinances accordingly are not at all binding on us; 2*dly*, It was full of very minute directions and regulations, designed, partly to keep the Israelites separate from the Gentiles, and faithful to the true God, but partly, by their hidden typical meaning, to foreshew and prepare the way for the Gospel revelation; 3*dly*, It was a theocracy; a system of direct, special, temporal government by God's extraordinary providence. And accordingly, the sanction of the Mosaic Law was not the rewards and punishments of a future state, but temporal blessings and judgments.

These are the points which it is the most important to keep clearly and constantly before the mind; for this reason among others: That mistaken notions on some of these points may endanger a man's christian faith, by giving rise to difficulties and objections much greater, than our religion—such as it really is—can ever be exposed to.

Objections there are, indeed, to which no complete answer can be given, except by shewing that there are much *stronger* objections on the opposite side. But none of the objections to the christian revelation, *such as it was really given*, are so strong as those brought against what it is sometimes *erroneously represented* to be.

Suppose, for instance, any one is taught to believe, as a part of his religion, that some portion of the Mosaic Law is binding on Christians; although the persons who teach this are far from being all of them agreed as to which precepts are binding, and which not; and although the Apostle Paul speaks most clearly of the Gentiles as not being at all "under the Law" (Rom. vi. 14), he would find in this a difficulty which is caused entirely by a misapprehension of Scripture.

Again, suppose a man to have taken up the notion that temporal blessings and calamities are now a sign of the Divine favour or displeasure towards individuals or nations, and that whenever some great calamity occurs, we are at liberty to declare that such and such a sin has called down the divine vengeance, this leaves an opening for objections which can never be got over; for he sees that bad men often escape such temporal calamities, while much better men are exposed to them; and he knows also that Jesus Christ and his apostles endured great affliction in this world, and were rejected by the Jews on that very ground. So that this doctrine would make Scripture contradictory both to itself and to daily experience.

And again, if he is taught that Moses was commissioned to reveal to the Israelites the doctrine of a resurrection, he will not be able to answer an infidel who may point out to him how very imperfectly (at best) the Books of Moses accomplish this purpose; and also, how completely at variance this is with the declaration that "Jesus Christ brought life and immortality to light." So that here, again, Scripture will be made to contradict itself.

All these will be great stumbling-blocks to the Christian. But when we look to the plain meaning of the Sacred Books, without attending to the fanciful theories of uninspired men, all these difficulties vanish.

As for the question, what will be the lot, in another world, of those Jews or Pagans who never heard of the Gospel, the only answer is, that the Gospel revelation contains instructions designed for those who *have* heard the Gospel, as to what their duty is, in living according to it themselves, and doing their best to impart it to others.

As for those whom Providence has shut out from the knowledge of it, all inquiries respecting *them* must be answered as our Lord answered Peter's inquiry what was to be the fate of the Apostle John: "What is that to thee? follow thou me." (John xxi. 21, 22.)

INTRODUCTION OF THE GOSPEL.

ALTHOUGH the Jews were in eager expectation at the time when the Lord Jesus appeared, of an ANOINTED Saviour (Messiah or CHRIST),[1] whom the predictions of their prophets had taught them to expect about that time, they did not expect Him to introduce anything that could be called a *new* religion; but rather to confirm and extend through the world the Mosaic Law. And this, it is well known, is what the unconverted Jews of this day expect.

Yet some of the prophecies relating to the Christ's kingdom, do contain allusions to the introduction of a *new* religion, distinct from that taught by Moses. The most decisive of these prophecies, in relation to this point, is that of Jeremiah,—"Behold the days come [are coming] saith the Lord, that I will make a NEW COVENANT with the House of Israel * * * * not *according to the covenant* that *I made with their fathers*," &c.

Now the system of divine Laws under which the Israelites lived, is, in the Books of Moses, always called (in our version) the "Covenant" which the Lord made with them. And in the Gospels and the Apostolic Epistles, the same word (in the Greek) is always applied to the christian system.

This, however, is likely to escape the notice of the mere English reader; because, in our version, the very same word *Diathekè* which, in *reference to the Mosaic Law*, is generally rendered COVENANT, is translated—when it has reference to the *Gospel*—by the word TESTAMENT.[2] And even in the very passage of Exodus (xxiv. 8) which is cited in the ninth chapter of the Epistle to the Hebrews, the very word which our translators had before rendered "*Covenant*," they have changed into "*Testament*." (Heb. ix. 20.) And yet the word is so far from having different meanings in reference to the *Law* and to the *Gospel*, that, on the contrary, both the Lord Jesus Himself and his Apostles most plainly draw a *parallel* between the two, and point out the circumstances of the former Covenants as types and shadows of the Gospel Dispensation.

In particular, as it was anciently the universal practice to ratify and sanction every kind of *Covenant* by the sacrifice of a *victim*, the shedding of whose blood was a necessary ceremony, so this took place in both cases.

Moses, on the occasion of the establishment of the LAW, offered a sacrifice, and sprinkled the blood of the victim on the people; saying, "Thi is the blood of the Covenant (Exod. xxiv. 8) [Testament] (Heb. ix. 20) which the Lord hath made with you." And the Lord Jesus, at the Last Supper, when about to offer up Himself as a sacrifice, says, on giving to the disciples the wine which represented his blood, that is, his life, "This cup is the new Testament [Covenant] in my blood, which is shed for you."

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[1] These words signify in the Hebrew and the Greek "The Anointed," from the ancient practice of anointing a *king*, or a *priest*, or a *prophet*, as a part of the ceremony of appointing him to his office.

[2] Yet in Gal. iii. 15–19, it is translated Covenant, and what is more remarkable, the very same words in the original are translated, Heb. viii. 6, "Mediator of a *Covenant*," and in Heb. ix. 15, "Mediator of a *Testament*."

It would be unsuitable in a work of this kind, to enter on the discussion of the interpretation of a disputed text, but it may be remarked:—

I. That the passage in Exod. xxiv., which is cited in Heb. ix., ought to have been translated in both by the same English words.

II. That though *we* are accustomed to connect the idea of a covenant [compact] with signing and sealing, and not with any *death* of a sacrificed victim; and again, are familiar with the idea of a man's bequeathing his property by a *will*, which is to take effect after his death,—with the Jews it was the reverse. They (as well as many other ancient nations, as may be seen in many passages of Homer) were accustomed to see every covenant ratified by the blood of a victim. And, on the other hand, *Wills* they had none; since the Mosaic Law disposed of a man's property at his death. Accordingly, no one, in writing to *Hebrews* (even though speaking of the Gospel alone), would have been likely to introduce a reference to Wills. But,—

III. The writer is evidently drawing a parallel between *the Mosaic Law* and the *Gospel*. Now the *Law* was not at all of the nature of a Will [Testament], not being bequeathed by Moses at his *death*, but fully established forty years before. And accordingly,

IV. We may observe, that, in the passage before us, the parallel drawn is not between Christ and *Moses*, but between Christ and the *victim* slain by Moses as the ratifier of the Covenant.

To speak of the death of a "Testator," therefore, totally destroys the parallel which plainly was in the writer's mind, and makes the whole passage unmeaning. But when the *death* spoken of is understood of the death of the sacrificed victim—even Jesus Christ, who offered Himself to die in our stead, and for our deliverance, the parallel which the writer is dwelling on becomes intelligible and striking.

The word Testament, therefore, whenever it occurs in Scripture, is always to be understood in the sense of "*Covenant*" [or "Dispensation"].

The Christian religion, then, though springing out of the Mosaic, of which it was the fulfilment and completion,[1] yet was in itself a *new* Religion. It was the *fruit*, of which the Mosaic Dispensation was the *blossom*. And it was as distinct from it, and in many respects unlike it, as a fruit compared with the blossom which precedes it and produces it.

The chief points which distinguish the Christian Dispensation from the Mosaic, are these three: 1. *Spirituality;* 2. *Universality;* and, 3. *Unity.* The new kingdom of God was to be "not of this world," but *spiritual;* it was to be open to *all* mankind as its subjects; and it was to admit all of them to *equal* privileges.

The former kingdom of God was a kingdom of this world. The Lord was, as has already been pointed out, not only the God, but the *temporal Ruler* of the Israelites; prescribing to them not only the religious rites with which He was to be worshipped, but also the civil regulations under which they were to live, and enforcing obedience by temporal rewards and penalties.

Jesus Christ, on the contrary, refused an earthly kingdom, when attempts were made to force it on Him, and declared that "his kingdom was not of this world." He disclaimed all right to interfere in temporal concerns; saying to one who wished Him to decide between him and his brother, "Who made me a judge or a divider over you?" He bid his hearers submit to the civil government of the Romans, saying, "Render to Cæsar the things that are Cæsar's, and to God the things that are God's." And, so far from promising victory, and long life, and worldly prosperity, to his followers, as a reward of their obedience to Him, He prepared them for suffering and death in his cause; even such as He endured Himself; and pronounced them "blessed when men should hate and persecute" them for His sake, saying, "great is your reward in heaven."

For, the rewards and punishments which formed the sanction of this New Dispensation were those of the next world, and those only. Jesus rebuked his disciples for proposing, in their zeal for his honour, to call down fire from heaven on a village which had rejected Him; as the Prophet Elias [Elijah] had been divinely commissioned to do, under the old dispensation. (Luke ix. 54.) Jesus reproved them, as "not knowing what manner of spirit *they* were of," He having "come not to destroy men's lives, but to save."

But this was not from his regarding a rejection of Him as *more pardonable* than the sins of those who had lived before the days of the Gospel. He taught the reverse of this. For shortly after, when He sent out seventy disciples to preach the Gospel, He denounced *heavier* judgments than what had fallen on sinners of old, against such as should reject that Gospel. "It shall be *more tolerable*," said He, "for Sodom and Gomorrah" (which did suffer destruction by fire from heaven) "in the day of judgment, than for that city." And while He forewarned his disciples that "in the world they would have tribulation," He promised to the faithful Christian "to raise him up at the last day," and to "prepare a place" for such, in his "Father's house."

Thus different was the New Dispensation from the Old, in respect of the *rewards and punishments* which formed the sanction of each.

The *Worship* also that was required under the Gospel, was of a more spiritual character than that prescribed by the Law.

It is true, the Israelites were commanded to "love the Lord their God, with all their heart, and with all their soul, and with all their strength." But a great part of their service of Him consisted (as the Apostle Paul expresses it) "in meats and drinks, and *carnal* ordinances"—that is, outward bodily acts; most of which had (as has been before observed) an inward hidden signification in reference to the Gospel.

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[1] "I am not come," says our Lord, "to destroy the Law and the Prophets, but to fulfil."

Jesus, on the contrary, tells the woman of Samaria, that the time is at hand "when the true worshippers shall, neither on Mount Gerizim, nor at Jerusalem, worship the Father;" but that they "shall worship Him in spirit and in truth." (John iv. 23.) What He means by worshipping in *truth*, and what the Apostle means by saying that "the law was given by Moses, but grace and *truth* came by Jesus Christ" (John i. 17), is, not that the Mosaic religion was not *true*, but that its ordinances contained the *shadow* of that of which the Gospel contains the substance. The *truth* of the Gospel is not (in reference to the Law) truth as opposed to *falsehood*, but *reality*, as contrasted with *shadows* and figurative representations. Thus, we read in the Epistle to the Hebrews, "If the blood of bulls and goats, &c., sanctify to the *purifying of the flesh*" (that is, remove *ceremonial* impurity, so as to enable a man to attend the assemblies of worshippers), "how much more shall the blood of Christ purify your conscience from dead works."

In the Mosaic religion, the number is very great of what may be not improperly called "Sacraments." For a large portion of the very numerous ordinances of the LAW—the various sacrifices, purifyings, and other ceremonial observances,—were of the nature of what *we* call Sacraments—that is, outward visible signs [figures], divinely appointed, and having an inward meaning connected with religion. The worship, in short, of the Israelites, may be considered as almost made up of Sacraments.

But a great part of the inward signification of these Sacraments was hidden from the worshippers; though they were taught that a divine blessing would accompany their observance of those rites, in pious obedience to the Lord. In the Passover, for instance, all that they understood as signified in that ordinance, was the commemoration of their deliverance from the plague which slew the Egyptians. But the more important part of its signification, the sacrifice of the true "Lamb of God, who taketh away the sin of the world," was not made known till the Gospel revelation appeared.

Under the Gospel, on the contrary, the religious rites instituted by Christ himself were only the Sacraments of Baptism and the Lord's Supper: the one for the admission of members into his Church, and the other to commemorate his death for man's redemption, and to represent our partaking of his Spirit. The one Sacrament denotes the spiritual *Birth* of the Christian; the other, the *continued support* of his Spiritual *Life*.[1]

And the signification of these two ordinances is much more clearly and fully explained to Christians in the New Testament Scriptures, than the signification of the Mosaic ordinances was in the Law. And moreover, the directions given as to the mode of observing these ordinances, are much less minute and particular than those given by Moses. For instance, there is nothing said in Scripture as to the use of *leavened* or unleavened bread at the Lord's Table;—or the posture of the communicants, or the words to be used, &c. These particulars, and also all other forms and ceremonies for religious worship, Jesus left to be regulated in and by each Church from time to time, with merely the general direction from the Apostles, "Let all things be done to edifying."

Under the LAW, in short, the worship prescribed contained a great number of *outward acts*, striking to the senses, and according to forms which were precisely laid down; while the *inward signification* of those forms was obscure and partially hidden. Under the Gospel, on the contrary, the worship prescribed was more spiritual; the external acts (as far as enjoined by Christ himself) being very few and simple, and without any precise directions as to the forms of them; while the inward signification of them is plainly made known.

And in what relates to *moral conduct* also, the precepts given under the New Covenant, are much less numerous and less precise than those of the LAW. Not that Christians were meant to be less scrupulously careful in leading a virtuous life than the Israelites; but that they are left to regulate their conduct by the PRINCIPLES of the Gospel, according to the best of their own judgment, instead of having a multitude of precise *precepts* laid down for their guidance.

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[1] John vi. 48–63. See also 1 Cor. xii. 13, where the Apostle gives exactly the above view of the two Sacraments, saying, "By one Spirit ye are all baptized into one Body * * * and have been all *made to drink* into one Spirit."

Just as the christian worship was left to be regulated as to its FORMS, from time to time, by each Church, under the *general principle* of all "being done to edifying," even so christian *practice* was left to be regulated by Christians themselves, in conformity with Gospel *principles*, and the examples set before us by Christ and his Apostles.

Thus not only does the Gospel require a morality in many respects higher and more perfect in itself than the Law, but it places morality universally on higher grounds.

Gratitude for the redeeming love of God in Christ, with mingled veneration and affection for the person of our great Master, and an exalted emulation, leading us to tread in his steps,—an ardent longing to behold his glories and to enjoy his presence in the world to come,—with an earnest effort to prepare for that better world,—love towards our brethren for His sake who died for us and them,—and, above all, the thought that the Christian is a part of "the temple of the Holy Ghost" who dwelleth in the Church,—even the Spirit of Christ, "without which we are none of His," a temple which we are bound to keep undefiled;—these, and such as these, are the sublime principles of morality, into a conformity with which the Christian is to fashion his heart and his life; and they are such principles as the Mosaic dispensation could not furnish.

The Israelites, as not only living under a revelation which had but a shadow of the good things of the Gospel, but also as a dull and gross-minded, and imperfectly civilised people, in a condition corresponding to that of childhood, were in few things left to their own moral discretion, but were furnished with precise rules in most points of conduct. These answered to the exact regulations under which children are necessarily placed, and which are gradually relaxed as they advance towards maturity; not by any means on the ground that good conduct is less required of *men* than children; but that they are expected to be more capable of regulating their own conduct by their *own* discretion, and of acting upon principle.

When, then, the Mosaic code was abolished, we find no other *system of rules* substituted in its place. Our Lord and His Apostles enforced such duties as were the most liable to be neglected,—corrected some prevailing errors,—gave some particular directions which particular occasions called for,—but laid down no set of *rules* for the conduct of a Christian: they laid down christian *principles* instead; they sought to implant christian dispositions. And this is the more remarkable, inasmuch as we may be sure, from the nature of man, that precise regulations, even though somewhat tedious to learn, and burdensome to observe, would have been highly acceptable to their converts. Hardly any restraint is so irksome to man (*i.e.* to "the natural man") as to be left to his own discretion, yet still required to regulate his conduct according to certain principles, and to steer his course through the intricate channels of life, with a constant vigilant exercise of his moral judgment. It is much more agreeable to human indolence (though at first sight the contrary might be supposed) to have a complete system of laws laid down, which are to be observed according to the letter, not to the spirit,—and which, as long as a man adheres to them, afford both a consolatory assurance of safety, and an unrestrained liberty as to every point not determined by them,—than to be called upon for incessant watchfulness,—careful and candid self-examination,—and studious cultivation of certain moral dispositions.

Accordingly, most, if not all systems of man's devising (whether corruptions of Christianity, or built on any other foundation) will be found, even in what appear their most rigid enactments, to be accommodated to this tendency of the human heart. When Mahomet, for instance, enjoined on his disciples a strict fast during a certain period, and an entire abstinence from wine and from games of chance, and the devotion of a precise portion of their property to the poor, leaving them at liberty, generally, to follow their own sensual and worldly inclinations, he imposed a far less severe task on them, than if he had required them constantly to control their appetites and passions, to repress covetousness, and to be uniformly temperate, charitable, and heavenly-minded. And had Paul been (as a false teacher always will be) disposed to comply with the expectations and wishes which his disciples would naturally form, he would doubtless have referred them to some part of the Mosaic Law as their standard of morality, or would have substituted some other system of rules in its place. Indeed, there is strong reason to think (especially from what we find in 1st Corinthians), that something of this nature had actually been desired of him. He seems to have been applied to for more precise rules than he was willing to give; particularly as to the lawfulness of going to idol-feasts, and as to several points relative to marriage and celibacy; concerning which and other matters, he gives briefly such directions as the occasion rendered indispensable, but breaks off into exhortations to "use this world as not abusing it;" and speedily recurs to the general description of the christian character, and the inculcation of christian principles. He will not be induced to enter into minute details of things forbidden and permitted,—enjoined and dispensed with; and even when most occupied in repelling the suspicion that Gospel liberty exempts the Christian from moral obligation, instead of retaining or framing anew any system of prohibitions and injunctions, he urges upon his hearers the very consideration of their being exempt from any such childish trammels, as a reason for their aiming at a more perfect holiness of life, on purer and more generous motives: "Sin," he says, "shall not have dominion over you; for *ye are not under the law but under grace:*" and he perpetually incites them to walk worthy of their vocation, on the ground of their being "bought with a price," and bound to "live unto Him who died for them;"—"as risen with Christ" to a new life of holiness,—exhorted to "set their affection on things above, not on things on the earth;"—as "living sacrifices" to God;—as "the temple of the Holy Ghost," called upon to keep God's dwelling-place undefiled, and to abound in all "the fruits of the Spirit," and as "being delivered from the Law, that we should serve in newness of the Spirit, and not in the oldness of the letter."

He who seeks, then (as many are disposed to do), either in the Old Testament, or in the New, for a precise code of laws by which to regulate his conduct, mistakes the character of our religion. It is indeed an error, and a ruinous one, to think that we may "continue in sin, because we are not under the law but under grace;" but it is also an error, and a far commoner one, to inquire of the Scriptures, in each case that may occur, what we are strictly bound to do or to abstain from, and to feel secure as long as we transgress no distinct commandment. But he who seeks with sincerity for christian *principles* will not fail to find them. If we endeavour, with the aid of the Holy Spirit, to trace on our own heart the delineation of the christian character which the Scriptures present, and to conform all our actions, and words, and thoughts, to that character, our heavenly Teacher will enable us to have a right judgment in all things, and we shall be "led by the Spirit" of Christ to follow *his* steps, and to "purify ourselves even as He is pure;" that when He shall appear, we may be made like unto Him, and may behold Him as He is.

Besides Spirituality, another striking feature of the Christian Dispensation, as contrasted with the Mosaic, is its UNIVERSALITY. It was to be *unlimited*, both in *time* and in *place.*[1] The Mosaic Law being only a preparation for the Gospel, was to come *to an end* on the establishment of the new Kingdom of Heaven, which is to *continue* to the end of the world.

And again, the Old Dispensation was designed for *one* nation; the New for *all* nations. The "People of God" was, henceforth, to comprise, not merely the "seed of Abraham after the flesh," but all mankind, as many as would embrace the Gospel. "As many as received Him (Jesus Christ), "to them gave He power to become the sons of God." (John i.) The language of Moses, and of those who came after him under the Law, was, "What nation is there so great, that hath God so nigh unto them, as the Lord our God is, in all things that we call upon Him for?" and "He hath not dealt so with any nation; neither have the heathen knowledge of his laws." The language of Jesus Christ and his Apostles was, "Go ye into all the world, and preach the Gospel to every creature:" "Go and teach (make disciples of) all nations:" "There is neither Jew, nor Greek, barbarian, Scythian, bond, or free." And in writing to Gentile believers, the Apostle calls them (Gal. vi. 16) "the Israel of God;" and says, "if ye are Christ's, then are ye Abraham's seed, and heirs according to the promise." (Gal. iii. 29.)

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[1] Hence the term Catholic (*καθολική*—universal) is applied to the Christian Church—specially in opposition to the Jewish. It may be remarked, by the way, that the term Roman Catholic does, in strictness of speech, imply a contradiction,—Roman suggesting a necessary connexion with one place, while Catholic denotes having *no* necessary connexion with any one place more than another.

Hence it was, no doubt, that the Apostles never applied the term "Christians"[1] to the members of any church. It was not, of course, that they were ashamed of it: but they seem to have chosen not to adopt any *new* title, but to confine themselves to those which had been applied to God's People of old; in order to point out that He had now admitted Gentiles into the number.

The Israelites had always been called "brethren," being of one race. They are also called a "*holy*" people ("saints"), as being dedicated to the Lord; and his "chosen" ["elect"] People. And hence Christians are called "the brethren," the "elect," and "saints," (ἁγίοι) that is *holy*, as being dedicated at baptism to the Lord Jesus.

One necessary circumstance in such a Dispensation, was, that it should not be like the Mosaic, a *local* religion. The Jews, indeed, clung (and still cling) to the notion that, even when all the world should be brought to the knowledge of the true God, still their nation should have a preeminence; and that the Temple of Jerusalem should be the great centre of religious worship for all mankind. And we know there are even some Christians who expect that Jesus Christ is to return to this earth in bodily person, and reign at Jerusalem in great worldly splendour for a thousand years. But such notions are quite at variance with the whole character of the Gospel, as described in our Sacred Books.

The Temple at Jerusalem—"the place which the Lord had chosen to cause his NAME to dwell there,"[2] that is, to manifest his presence—was to be totally and finally destroyed. And Jesus declared, that "wheresoever even two or three should be gathered together in his name, He would be there in the midst of them." And hence, a christian *congregation*—not a literal building—was to be henceforth a portion of the temple of the MOST HIGH.

"Know ye not," says the Apostle Paul, "that your bodies are a temple of the Holy Ghost, which dwelleth in you?" (1 Cor. vi. 19.)

And as the collective body of worshippers was called a *temple*, so the individual Christians are called "*living stones*" of God's temple. "Ye as living stones, are builded together into an holy temple to the Lord" (1 Peter ii. 6). Hence arose the use of the word "edify," (οἰκοδομεῖν) literally "to build up"—as applied to christian instruction and exhortation.

While Jesus Christ was on earth in bodily person, HE was the temple of the Lord; inasmuch as "in Him dwelleth all the fulness of the Godhead bodily" (Col. ii. 9). And accordingly, He not only speaks expressly "of the temple of his body"[3] (John ii. 21), but makes several allusions[4] (which are often overlooked) to this character of Himself.

And this, by the way, is a clear proof of his claiming a *divine* character. For the Jews understood (as He well knew) by "the temple of the Lord," not a synagogue,—a place of assembly for worshippers, but "the habitation where his honour (glory) dwelleth."

And it is worth remarking, that they also understood his calling Himself the "Son of God," and saying, "that God was his *own proper*[1] Father," as a claim to be a divine person. His words, indeed, might, in themselves, conceivably, bear another meaning. But He must have *known* that *they* so understood Him. And if they had mistaken his meaning, He would not have failed to correct their mistake: else He would have been bearing false witness against Himself.

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[1] The word Christian (Χριστιανὸς) occurs but three times in the New Testament, Acts xi. 26, xxvi. 28; I Peter iv. 16.—In no one of these places do we find it *applied by Christians themselves to one another*. It is mentioned as a name first given to the disciples at Antioch in Syria, doubtless by the Romans, as the word is of Latin formation. King Agrippa, again, uses the word in speaking to Paul, and the Apostle Peter introduces it as denoting what was accounted a crime by the heathen rulers. "If any man suffer for being a Christian, let him not be ashamed."

[2] There are two words in the original which are both translated "Temple," Ἱερον, that is, the "sacred place," which included the courts of the Temple; and Ναὸς, (from Ναιω, "to dwell,") the "House of God," which was the building in which *sacrifices* were offered. For this was the main purpose of a temple; which was not (like the synagogues, and like our churches and chapels) a place for religious assemblies.

Ναος is the word used by our Lord when he calls his body a temple, and by Paul, when he applies it to Christians.

[3] ἔλεγε περὶ τοῦ ναοῦ τοῦ σώματος αὐτοῦ.

[4] So the Evangelist—"The Word became flesh and tabernacled" (ἐσκήνωσε) not merely *dwelt*, as in our version, "among us."

They *rightly* understood Him, therefore, to be claiming a divine character. And thereupon they pronounced him guilty of blasphemy (Matt. xxvi. 65), and liable to death by their Law (Deut. xviii. 20), as teaching men to worship another besides the true God.

For they did not expect that the Christ was to be a *divine* person; as is plain from their being unable to solve the question which Jesus put to them, about David's calling him LORD (Mark xii. 37). When therefore, they understood Him to "make Himself God" (John x. 33), this was so far from favouring their belief in him as the Christ, that it convinced them of his being a false pretender and a blasphemer.

When Jesus departed from the earth, He sent to his disciples the promised "Comforter," to abide with them for ever;" even the Holy Spirit, whose temple is the whole body of Christians throughout the world. And every christian congregation, as has been already observed, is a portion of this temple; each individual Christian being called in Scripture a "living stone" of it.

But our Lord takes care to make his disciples understand that it is not a *different Being* they are to look for, and who is to be their new Master; but a different *manifestation* of the same God;—a return of their Master to them under a new character. For He says expressly, "I will not leave you *comfortless, I will come* unto you:" —"*I* will *see you again;* and your heart shall rejoice; and your joy no man *taketh from you;*"— "if any man love me, he will keep my saying, and my Father will love him; and We will come unto him, and make *our abode with him.*" And the like, in several other passages.

And the Apostles, accordingly, speak of "the LORD (that is, Jesus Christ) being the *Spirit* (2 Cor. iii. 17), and assure us that "if any man have not the Spirit of Christ, he is none of his." (Rom. viii. 9.)

The same God, then, who to the Israelites, was made known only as *Creator and Governor* (God the Father), was afterwards manifested to Christians as being also the *Redeemer* (God the Son), and the *Sanctifier* (God the Holy Ghost): and He is to be acknowledged by them in this threefold manifestation, according to our Saviour's injunction to "baptise in[2] the Name of the Father, and of the Son, and of the Holy Ghost."

There have been, therefore, in all, three *Temples* of the ONE GOD; first, under the Old Dispensation, the Temple at Jerusalem; secondly, during the abode on earth of the Lord Jesus, "the Temple of his Body;" and, thirdly, (that which is also often called Christ's body,) (Eph. iv. 12, 16), the holy Catholic or Universal Church, comprising all believers throughout the world.

This third and final manifestation of the ONE GOD plainly belongs to a Dispensation characterised (as we have said) by UNIVERSALITY.

Another distinguishing feature of the New Dispensation, was, as has been said, its UNITY (or *Oneness*); by which we mean, that it not only admits all mankind to christian privileges, but all of them to *equal* privileges. "There is," as the Apostle expresses it, "one Lord, one faith, one baptism." "There is neither Greek, nor Jew, barbarian, Scythian, bondman, or freeman." (Eph. iv. 5, and Col. iii. 11.)

This christian unity (ἑνότης) is often alluded to, and earnestly dwelt on, by our Sacred writers. But the passages relating to it are sometimes imperfectly understood, or entirely mistaken.

It does not mean *agreement* in *doctrine*, nor yet *concord* and mutual good-will; though these are strongly insisted on by the Apostles. But the *unity* which they speak of is something distinct from these.

Nor, again, does it mean that all Christians belong, or ought to belong, to some *one society on earth.* For this is what the Apostles never aimed at, and what never was actually the state of things, from the time that the christian religion extended beyond the city of Jerusalem.

The teaching of Scripture upon this subject, clearly is, that believers on earth are part of a great society (church or congregation), of which the Head is in heaven, and of which many of the members only " live unto God," or exist in his counsels,—some having long since departed, and some being not yet born. Of such a community *the centre* cannot possibly be on earth; and, accordingly, the Apostle Paul expressly distinguishes the christian church [assembly or congregation] ἐκκλησία, from that of Israel:—" Ye [that is, ye Christians] are not come to the mount that might be touched; [as the Israelites were collected in a great assembly (those of them that *were alive that day*) round Sinai, as a holy place on earth] . . . . but ye are come to Mount Sion, and unto the city of the living God, *the heavenly Jerusalem*, and to an innumerable company of angels, to the general assembly and church of the first-born, which are written in heaven, and to God the Judge of all, and to the spirits of just men made perfect, and to Jesus the mediator of the new covenant" (Heb. xii. 18–24). So, in the Epistle to the Galatians,—" Mount Sinai answereth to Jerusalem which now is, and is in bondage with her children; but Jerusalem *which is above* is free, *which is the mother* of us all." (Gal. iv. 25, 26.)

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[1] πατέρα ἴδιον. John v. 18.

[2] More properly *to* or *into* the Name, εἰς τὸ ὄνομα.

The Universal Church of Christ may therefore be said to be ONE in reference to HIM, its supreme Head in *heaven;* but it is not *one Community* on earth. And even so the *Human race* is *one*, in respect of the *one Creator* and *Governor;* but this does not make it *one Family*, or one *State*.

All men, again, ought to live in *peace*, and to be kindly disposed towards every fellow-creature. And all are bound to *agree* in thinking and doing whatever is right. But they are not at all bound to live under one *single government*, extending over the whole World. Nor, again, are all nations bound to have the *same form* of government, regal or republican, &c. That is a matter left to their discretion. But all are bound to do their best to promote the great *objects* for which all government is instituted;—good order, security of person and property, justice, and public prosperity.

And even so the Apostles founded christian communities, all *based* on the *same principles*, and having the same *object* in view, but quite independent of each other, and having no one common Head on Earth.

The Apostles, indeed, exercised a general government over the various churches which they founded; but it does not appear that they appointed any persons to succeed them in that *general* government. We read of their appointing "Elders in every city," but we do not read of their setting, or intending to set, any one *over the whole Church.*

Any one who looks at the account of Paul's taking leave of the Elders of Ephesus and Miletus (Acts xx.), *whom he expected never to see again*, will plainly see that he could not possibly have had any notion of any supreme *central authority*, lodged either in the church of Jerusalem, or of Rome, or in Peter and his successors, or in any *General Council.* For he there directly foretells that false teachers should arise out of their own body [that is, from amongst the clergy], and anxiously impresses on them the best advice he could think of for guarding against such a danger. Yet that advice is only *to watch, and remember what he had taught them.* This seems to imply that each particular church was left sufficient *means* within itself of ascertaining the true doctrine of Christ, continuing, and preserving it; but that the actual preservation of such doctrine depended on the *watchfulness* of the churches themselves. For the occasion was one on which he could not have failed to bid them have recourse, in case of any difficulties or disputes among themselves, (such as he actually foresaw,) to some central Authority, if any such had existed, or were to be set up.

Nor does the Apostle Peter (though writing his Second Epistle in the near prospect of death (2 Pet. i. 14, 15), and anxious to provide a record of his teaching that might last after his decease), say a word to the disciples of the duty of submitting to his successors; but refers them back for guidance to the words of the holy prophets, and the commandments of the apostles, and to his own letters, and to those of Paul.

In the beginning of the Revelation of John, too, we find the Lord addressing *each* of *the seven churches of Asia* as severally independent of any earthly power, and responsible to Him alone for their conduct as christian churches.

It is plain, therefore, that the christian Unity spoken of in Scripture did not consist in the placing of all Christians in one Society under one government on Earth.

It consisted (as we have said) in the admission of all men to equal christian privileges, instead of having two or more different kinds or *degrees* of Christianity, for different classes of persons.

Now, there did exist something of this kind under the Mosaic Dispensation. The "devout Gentiles" (sometimes called "Proselytes[1] of the Gate"), were admitted to worship in the outer court of the Temple, and to frequent the Synagogues. Those who had embraced the whole Mosaic Law (who were called "Proselytes of righteousness") were accounted as ranking higher than the others, and next in holiness to the Israelites by birth. Then, of the born Israelites, the *Levites* were more especially dedicated to the Lord than those of the other Tribes, and were employed in his immediate Service about the Tabernacle, or the Temple. Of the Levites themselves, again, the family of Aaron were alone admissible to the priesthood. And lastly, of the Priests themselves, none except the high priest was permitted to enter the Holy of Holies,—where he offered the yearly sacrifice on the great day of atonement.

And these several gradations, it is to be observed, are something quite different from the various degrees of moral worth and piety, or of intelligence and knowledge, in individuals.

One Israelite (and the like may be said of Christians) might exceed another of the same Tribe and Family, in pious obedience to the Lord; and a third might surpass them both. But these differences would not be distinctions *introduced by the Mosaic Religion;* but merely those of the individual characters of those men. And again, a pious Israelite, of superior understanding, and of a reflecting turn of mind, and of more extensive knowledge than the generality, would have a clearer, and more intelligent, and more comprehensive view of some parts of the Revelation given him, and of God's Providence generally, than another, equally pious, but of humbler powers and attainments. And the like must be the case with Christians also.

But these differences between one man and another, are such as we find to exist in reference to *all* subjects, and do not particularly pertain to the Mosaic system of Religion; not being introduced and created by it.

Those distinctions, on the contrary, which were noticed just above, are such as did specially belong to the religion of Moses, and formed a part of the Dispensation.

The Gospel, on the other hand, admitted of no such gradations as those established under the Law.

Various Officers, indeed, were appointed in the christian churches; because no Society can subsist without them. But all persons, of whatever Race or Family, were admissible, if properly qualified, to any Office.

And again, (as was said just above,) men of superior intelligence and mental cultivation, will be able, by piously and humbly employing their powers in the study (among other things) of the christian Scriptures, to take a clearer and more intelligent view of the Gospel revelation, than those of ordinary abilities and education; provided they are careful not to indulge in rash conjectures respecting things beyond human reason, and which God has not thought fit to reveal.

Such men, if they do use this care, will find that the more they advance in general cultivation of mind, the more will the prospect of divine wisdom and goodness spread around them; the horizon, as it were, extending itself in proportion to their elevation.

But this (as was observed above) is a kind of distinction between man and man, which was not *introduced by the Gospel*, but takes place in *all* subjects.

Nor does such a distinction make one man *more a Christian*, properly speaking, than another. In fact, a learned Philosopher would be a *worse* Christian than pious men of ordinary ability and education, if he were content to remain, in point of religious knowledge, just *on a level* with these, while in all *other* matters he was intellectually superior to them. He would be like a person offering as the *tithe* of an increased produce, the same *absolute* amount as would be a fair proportion from a smaller or less fertile field.

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[1] *ϖροσήλυτος*, one who *comes over to* some religion or religious sect.

And in respect of piety of sentiment, also, and purity of conduct, one man may be a better Christian than another, that is, he may make a *better use* of his christian privileges. But the *Gospel itself* does not exclude any man from any christian privileges to which it admits others.

This is one of the points wherein (as has been said) it differs from the Mosaic Law.

And this feature of the Gospel was one which proved a great stumbling-block to the Jews. They could not easily reconcile themselves to the thought of Gentiles being placed completely on a level with them. And they clung to the idea that the Jews by Race must continue to be in an especial manner God's peculiar People, even when both they and the Gentiles should have become subjects of Christ's kingdom. And even among the Gentile Christians themselves, there seems to have been a tendency to consider the different "spiritual [miraculous] gifts" bestowed on different persons, as dividing Christians into so many distinct Orders. This tendency we find the Apostle Paul earnestly contending against in several parts of his writings; especially in 1 Cor. xii.

The miraculous gifts were bestowed not for the benefit of the possessor, but of the Church. And they did not either *prove* the possessor to be peculiarly acceptable to God, or necessarily *make* him so. For Judas Iscariot, who afterwards betrayed his Master, had been endowed, along with the other Apostles, with miraculous powers. And our Lord declares that He will say, at the Day of Judgment, to some who should boast of having, in his Name, "done many mighty works," "I know you not; depart from me, all ye workers of iniquity."

Yet in all ages of the Church, there has been a tendency, more or less, to draw some unwarranted distinctions between ordinary Christians, and those to whom the name of SAINTS has been confined, either from their having been inspired, like the Evangelists and Apostles, or from their being supposed to possess some extraordinary personal holiness, beyond what is expected of Christians generally.

The Apostles, on the contrary, (as was observed above,) call *all* Christians "Saints;" as being all *dedicated* to Christ in Baptism, and all admitted to be equal partakers (as far as relates to their own holiness of character, and power of becoming acceptable to God) of his sanctifying Spirit. There is no hint given that a less degree of personal holiness will suffice for us, than for an Apostle; and Peter, or Paul, however superior to us in their miraculous gifts, yet called themselves Saints in reference not to any thing *peculiar* to them, but to what was *common* to them with us.

Nevertheless, one may find persons, even now, who seem to regard Christianity as not, in reality, one religion, but two; one, for persons of pre-eminent holiness, or who are admitted to certain superior christian privileges, beyond the generality; and the other for the multitude; who are to believe implicitly whatever the most eminent Saints think fit to impart, and to do whatever they bid them.

But nothing can be more at variance than such a notion is with the whole character of the Gospel Dispensation. For this was designed as a revelation to men of all classes, in every tolerably-civilised country. And the endeavour of the Apostles was to "*make known* the *mystery* of the Gospel" to *all*, in proportion as they were *able* and *willing* to receive it. And they laboured, by assiduous instruction and exhortation, to *make* men, more and more, thus able and willing. They urged them to "*grow* in grace and in the knowledge of the Lord Jesus Christ." And they reckoned themselves to be "pure from the blood of all men," only inasmuch as they "had not shunned to declare to them *all* the counsel of God."

When we look back to these distinguishing points in the Gospel Dispensation which have been here noticed—its *Spirituality*, *Universality*, and *Unity*—as well as to several other remarkable features of it, we cannot but perceive what a strong confirmation they afford of its divine origin.

It was altogether the most unlikely thing to have occurred to the mind of any man, whether dreaming enthusiast or crafty impostor. And of all men, *Jews* were the most unlikely to have imagined anything of the kind. Indeed, the great stumbling-block to the Jews was its being so utterly at variance (as has been remarked above) with all their most deeply-rooted prejudices, and all their long-cherished hopes.

But it was almost equally at variance with many of the notions of the Heathen also. And these latter had nearly as much difficulty in receiving a religion from Jews—a people generally despised by them—as the Jews had, in acknowledging the "Gentiles" as fellow-heirs with themselves. And both parties—Jews and Gentiles—had never conceived an idea of such a thing as a religion without any literal *Temple*, without an *Altar*, without Sacrifices, and without any Sacrificing Priest on earth.

Such a Religion could never have been *invented*, in those days, by any man, Jew or Gentile; and could never have been established throughout the chief part of the civilised World, except by the overpowering force of miraculous proofs.

ESTABLISHMENT OF CHRIST'S KINGDOM.

WHEN the bodily presence of our Divine Master was withdrawn from the earth, his Apostles proceeded, according to his directions, to establish "the kingdom of heaven," over which He had placed them, saying, "I appoint unto you a kingdom, as my Father hath appointed unto me."

For, that Gospel which had been proclaimed by Himself and his disciples, during his personal ministry, was, that "the kingdom of heaven was *at hand*." That kingdom was *then* only in preparation. It was not completely begun, till the Apostles, after the outpouring on them of the Holy Spirit, on the day of Pentecost, founded at Jerusalem the first christian church, and baptized into the Name of the Lord Jesus about three thousand persons, who were thus enrolled as subjects of that kingdom.

The number of these in Jerusalem increased rapidly. Other churches were established in Judea, in Galilee, in Samaria, and elsewhere. And a few years after, the apostles having learnt by an express revelation—quite contrary to their own expectations—that Gentiles were to be admitted, on equal terms, as subjects of Christ's kingdom, great numbers of churches, consisting chiefly of these, arose in various parts of the world.

Although, however, mention is made in Scripture of several of these churches, we have only incidental, slight, and scanty accounts of the way in which the Apostles proceeded in founding them. Very few particulars are given of the regulations established,—of the appointment of the several Orders of Ministers,—of the Divine Service celebrated,—or, in short, of any of the details of matters pertaining to a christian church.

One reason for this, probably, was, that a Jewish Synagogue, or a collection of Synagogues in the same neighbourhood, *became* at once a *christian Church*, as soon as the worshippers, or a considerable portion of them, had embraced the Gospel, and had separated themselves from unbelievers. They had only to make such additions to their public Service, and such alterations, as were required by their reception of the Gospel; leaving everything else as it was. For, the Apostles, we know, acted on the rule of "becoming all things to all men;" that is, of complying with men's habits, and avoiding all shock to their feelings, as far as this could be done without any sacrifice of principle, or detriment to the great objects proposed. It is incredible, therefore, especially considering that for several years the only converts were persons frequenting the synagogues,—Jews or devout Gentiles,—that they should have utterly disregarded all the existing and long-reverenced Institutions and Offices, which could so easily be accommodated to the New Dispensation. To have established everything on a perfectly new system, through mere love of novelty,—to have erected, as it were, a fresh building from the very ground, when there was one standing which with small and easy alterations would answer all the same purposes, would have been to raise up, wantonly, difficulties and obstacles to their own success. They did not indeed, no doubt, think themselves bound or authorised, to adhere blindly to existing institutions in any points in which these were at variance with the spirit of the Gospel, or were capable of being changed for the better: and doubtless they introduced from time to time, (and designed that their successors should do the same,) such alterations in the functions of the several officers, and in all regulations respecting other non-essential points, as circumstances of time and place might require. But we cannot suppose that they aimed at originality for its own sake, or altered for the sake of altering. And the correspondence, accordingly, which has been traced by learned men between the Synagogue and the Church, is no more than what we might antecedently have expected.

The attempt to effect this conversion of a Jewish synagogue into a christian church, seems always to have been made, in the first instance, in every place where there was an opening for it. Even after the call of the idolatrous Gentiles, it appears plainly to have been the practice of the Apostles Paul and Barnabas, when they came to any city in which there was a synagogue, to go thither first and deliver their sacred message to the Jews, and "devout (or proselyte) Gentiles;"—according to their own expression (Acts xiii. 16); to the "men of Israel," and those "*that feared God;*"—adding, that "it was necessary that the word of God should first be preached to them."

And when they founded a church in any of those cities in which (and such were probably a very large majority) there was no Jewish Synagogue that received the Gospel, it is likely they would still conform in a great measure to the same model.

Now, Jewish synagogues, and all things pertaining to them, were so familiarly known in the days of our sacred writers, that there was no need to enter into any minute particulars respecting the officers, regulations, and practices of a synagogue.

Nevertheless, it seems probable that we should have found in Scripture something more than we do find, of incidental notices of some of these particulars, if there had not been some especial reason for omitting them.

The same may be said with respect to the Creeds, Catechisms, and Forms of Prayer, and of administering the Sacraments, which were in use in the days of the Apostles. We have no record in Scripture of any of these. And yet the more we reflect on the subject, viewing not merely the abstract probabilities of the case, but also what has actually occurred in respect of other religions, the more strongly we shall feel that the first founders of a religion might naturally have been expected to have transmitted to posterity some, more or less systematic, compositions, such as we have been speaking of.

For if we look, for instance, to the Koran, we find Mahomet, in the midst of much extraneous matter, fitted only to gratify the appetite for the marvellous, inserting, however, also, not only a precise description of the Mahometan Faith, but likewise minute directions concerning Fasts, Prayers, Ablutions,—the amount of Alms,—and all other points of the Mussulman's service of God. The same is represented to be the character of the Hindoo Shaster, and other Pagan books professing to contain a divine revelation of any system of religion.

And that there is nothing in the christian religion, considered in itself, that stands in the way of such a procedure, is plain from the number of works of this description which have appeared from the earliest times, (*after the age of inspiration,*)[1] down to the present;—from the writings entitled the "Apostles' Creed," and the "Apostolical Constitutions," &c. (compositions of uncertain authors, and amidst the variety of opinions respecting them, never regarded as Scripture), down to the modern Formularies and Confessions of Faith.

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[1] A proof, it should be observed, is thus afforded, that the New Testament Books are no *forgery* of the early Christians, since these would have been sure to insert what we do find in their own acknowledged writings, and which is altogether wanting in the Sacred Books.

The same inference may be drawn from a fact which we have already spoken of, the entire absence in the New Testament of the title of *Christians*, as applied by themselves to each other. It seems to have been adopted by Christians very early; probably soon after the destruction of Jerusalem; and if the Books of the New Testament had been forged or interpolated by them, at that, or at any subsequent period, there can be no doubt we should have found it frequently so employed therein.

Nor, again, can it be said that there was anything in the founders of the religion, any more than in the religion itself, which, humanly speaking, should seem likely to preclude them from transmitting to us such compositions. On the contrary, the Apostles were brought up Jews; accustomed, in their earliest notions of religion, to refer to the Books of the Law, as containing precise statements of their belief, and most minute directions as to religious worship and ceremonies. So that, to give complete and regular instructions as to the character and the requisitions of the new religion, as it would have been natural for *any* one, was more especially to be expected of *these* men.

And even supposing that the other avocations of the Apostles would not allow any of *them* leisure for such compositions,—though we know that some of them did find time for writing, two of them not a little,—even this supposition does not at all explain the difficulty; for the Acts and two of the Gospels were written by men who were only attendants on the Apostles. Nor would such writings as we are speaking of have required an *inspired* penman; only one who had access to persons thus gifted. We know with what care the Apostolic Epistles were preserved, first by the churches to which they were respectively sent, and afterwards, by the others also, as soon as they received copies. How comes it, then, that no one of the Elders (Presbyters) of any of these Churches should have written down, and afterwards submitted to the revision of an Apostle, that outline of catechetical instruction—that elementary introduction to the christian faith—which they must have received at first from that Apostle's lips, and have afterwards employed in the instruction of their own converts? Why did none of them record any of the prayers, of which they must have heard so many, from an Apostle's mouth, both in the ordinary devotional assemblies, in the administration of the Sacraments, and in the "laying on of hands," by which they themselves had been ordained.

Paul, after having given the most general exhortations to the Corinthians for the preservation of decent regularity in their religious meetings, adds, "the rest will I set in order when I come." And so, doubtless, he did; and so he must have done, by verbal directions, in all the other churches also: is it not strange then, that these verbal directions should nowhere have been committed to writing?

This would have seemed a most obvious and effectual mode of precluding all future disorders and disputes; as also the drawing up of a compendious statement of christian doctrines, would have seemed a safeguard against the still more important evil of heretical error. Yet if any such statements and formularies *had* been drawn up, with the sanction, and under the revision of an Apostle, we may be sure they would have been preserved and transmitted to posterity, with the most scrupulous and reverential care. The conclusion therefore seems inevitable, that either no one of the numerous Elders and Catechists ever thought of doing this, or else that they were forbidden by the Apostles to execute any such design: and each of these alternatives seems alike inexplicable by natural causes.

For it should be remembered that, when other points are equal, it is much more difficult to explain a *negative* than a *positive* circumstance in our Scriptures. There is something, suppose, in the New Testament, which the first promulgators of Christianity—considered as mere unassisted men—were not likely to write; and there is something else which they were, we will suppose, equally unlikely to omit writing; now, these two difficulties are far from equal. For with respect to the former, if we can make out that *any one* of these men might have been, by nature or by circumstances, qualified and induced to undertake the work, the phenomenon is solved. To point out even a single individual able and likely to write it, would account for its being written. But it is not so with respect to the other case, that of omission. Here we have to *prove a negative*;—to show, not merely that this or that man was likely not to write what we find omitted, but that *no one was* likely to write it. Suppose we could make out the possibility or probability of Paul's having left no Creed, Catechism, or

Canons, why have we none from the pen of Luke, or of Mark? Suppose this also explained, why did not John or Peter supply the deficiency? And why, again, did none of the numerous Bishops and Presbyters whom they ordained, undertake the work, under their direction? The difficulty, therefore, in this case exceeds the other, *cæteris paribus*, more than a hundredfold.

Since, then, no one of the first promulgators of Christianity did that which they must—some of them at least—have been *naturally* led to do, it follows that they must have been *supernaturally* withheld from it; how little soever we may be able even to conjecture the object of the prohibition. For in respect of this, and several other (humanly speaking, unaccountable) circumstances in our religion, it is important to observe, that the argument thence derivable in favour of the divine origin of Christianity, does not turn on the supposed *wisdom* of this or that appointment, which we conceive to be worthy of the Deity, and thence infer that the religion must have proceeded from Him; but on the utter improbability of *its having proceeded from Man;* which leaves its divine origin the only alternative. The christian Scriptures considered in this point of view, present to us a standing Miracle; at least, a Monument of a Miracle; since they are in several points such as we may be sure, according to all natural causes, they would *not* have been. Even though the character which these writings do in fact exhibit, be such as we cannot clearly account for on *any* hypothesis, still, if they are such as we can clearly perceive no false pretenders would have composed, the evidence is complete, though the difficulty may remain unexplained.

Although, however, we cannot pretend, in every case, to perceive the reasons for what God has appointed, it is not in the present case difficult to discern the superhuman wisdom of the course adopted. If the Hymns[1] and forms of Prayer,—the Catechisms,—the Confessions of faith,—and the Ecclesiastical regulations, which the Apostles employed, had been recorded, these would have all been regarded as parts of *Scripture:* and even had they been accompanied by the most express declarations of the lawfulness of altering or laying aside any of them, we cannot doubt that they would have been in practice most scrupulously retained, even when changes of manners, tastes, and local and temporary circumstances of every kind, rendered them no longer the most suitable. The Jewish ritual, designed for one Nation and Country, and intended to be of temporary duration, was fixed and accurately prescribed. The same Divine Wisdom from which both dispensations proceeded, having designed Christianity for all Nations and Ages, left Christians at large in respect of those points in which variation might be desirable. But we think no *human* wisdom would have foreseen and provided for this. That a number of *Jews*, accustomed from their infancy to so strict a ritual, should, in introducing Christianity as the second part of the same Dispensation, have abstained not only from accurately prescribing for the use of all Christian Churches for ever, the mode of divine worship, but even from recording what was actually in use under their own directions, does seem utterly incredible, unless we suppose them to have been restrained from doing this by a special admonition of the Divine Spirit.

And we may be sure, as we have said, that if they *had* recorded the particulars of their own worship, the very words they wrote would have been invested in our minds with so much sanctity, that it would have been thought presumptuous to vary or to omit them, however inappropriate they might have become. The Lord's Prayer, the only one of general application that is recorded in the Scriptures, though so framed as to be suitable in all Ages and Countries, has yet been subjected to much superstitious abuse. A superstitious Christian mutters his "paternosters," as a kind of sacred charm, on all occasions, however inappropriate.

In like manner, the Apostles' Creed, from its acknowledged antiquity, together with the title it bears, and the tradition (probably, in part, true[1]) of its being the composition of the Apostles, is held by many Christians in a kind of veneration which may justly be characterised as superstitious. There are persons of the lower orders, and some above the very lowest, who are accustomed to recite it in their private devotions as a *prayer*.

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[1] Pliny's account of the early Christians, derived in part from those who had belonged to the Society, mentions that they recited "a hymn to Christ, as to a God." This ancient hymn has not been transmitted to us, so as to be recognised. It is not unlikely, however, that it, or some part of it, formed the basis of that which we call the *Te Deum*.

No doubt there must ever be danger of all prayer degenerating into a superstitious formalism; but this danger must evidently be increased in proportion as the words uttered are the less appropriate to the occasion, and to the circumstances of the petitioner; and this must inevitably have been more likely to take place with a Liturgy transmitted to us from the times of the Apostles, as a part of Scripture.

With respect to Catechisms again,—elementary introductions to the christian faith,—nearly the same reasons will hold good. For though the christian religion is fundamentally "the same yesterday, and to-day, and for ever," it is impossible that any one mode of introducing its truths to the mind of the catechumen, can be the best adapted for children and adults,—the civilized and the barbarian,—and for all the other varieties of station, sex, country, intellectual culture, and natural capacity.

Each church, therefore, was left, through the wise foresight of Him who alone "knew what is in Man," to provide for its own wants as they should arise;—to steer its own course by the Chart and Compass which his holy Word supplies, regulating for itself the Sails and Rudder, according to the winds and currents it may meet with.[2] "The Apostles had begun and established precedents, which, of course, would be naturally adopted by their uninspired successors. But still, as these were only the formal means of grace, and not the blessing itself, it was equally to be expected that the church should assume a discretionary power, whenever the means established became impracticable or clearly unsuitable, and either substitute others, or even altogether abolish such as existed . . . . . It might seem at first that the apostolical precedents were literally binding on all Ages; but this cannot have been intended; and for this reason, that the greater portion of the apostolical practices have been transmitted to us, not on apostolical authority, but on the authority of the uninspired church; which has handed them down with an uncertain mixture of its own appointments. How are we to know the enactments of the inspired rulers from those of the uninspired? and if there be no certain clue, we must either bring down the authority of apostolical usage to that of the uninspired church, or raise that of the uninspired church to that of the apostolical. Now, the former is, doubtless, what was, to a certain extent, intended by the Apostles themselves; as will appear from a line of distinction by which they have carefully partitioned off such of their appointments as are designed to be perpetual, from such as are left to share the possibility of change, with the institutions of uninspired wisdom.

If, then, we look to the account of the christian usages contained in Scripture, nothing can be more unquestionable than that, while some are specified, others are passed over in silence. It is not even left so as to make us imagine that those mentioned may be all: but, while some are noted specifically, the establishment of others is implied, without the particular mode of observance being given. Thus, we are all equally sure from Scripture, that christian ministers were ordained by a certain form, and that Christians assembled in prayer; but while the precise process of laying on of hands is mentioned in the former institution, no account is given of the precise method of Church-Service, or even of any regular forms of prayer, beyond the Lord's Prayer. Even the record of the Ordination Service itself admits of the same distinction. It is quite as certain, that, in it, some prayer was used, as that some outward form accompanied the prayer; but the form is specified, the prayer left unrecorded.

What, now, is the obvious interpretation of the holy Dispenser's meaning in this mode of record? Clearly, it is, that the Apostles regulated, under his guidance, the forms and practices of the

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[1] If, as there seems good reason for thinking, part of this creed was actually in use with the Apostles, this circumstance renders it the more remarkable that it should not have been recorded by them in their writings.—See KING'S (afterwards Lord King) *History of the Apostles' Creed.*

[2] Bishop HIND'S *History of the Rise and Progress of Christianity.*

Church, so as was best calculated to convey grace to the Church *at that time.* Nevertheless, part of its institutions were of a nature, which, although formal, would never require a change ; and these, therefore, were left recorded in the Scriptures, to mark this distinction of character. The others were not, indeed, to be capriciously abandoned, nor except when there should be manifest cause for so doing; but as such a case was supposable, these were left to mingle with the uninspired precedents, the claims of which as precedents would be increased by this uncertain admixture, and the authority of the whole rendered so far binding, and so far subject to the discretion of the church. They might not be altered, unless sufficient grounds should appear; but the settling of this point, was left to the discretion of the church."[1]

The Apostles themselves, however, and their numerous fellow-labourers, would not, probably, have been, if left to themselves, so far-sighted as to perceive (all, and each of them, without a single exception) the expediency of this procedure. Most likely, many of them,—but according to all human probability, some of them,—would have left us, as parts of Scripture, compositions such as we have been speaking of; and these, there can be no doubt, would have been scrupulously retained for ever. They would have left us Catechisms, which would have been like precise directions for the cultivation of some plant, admirably adapted to a particular soil and climate, but inapplicable to those of a contrary description. Their Symbols would have stood like ancient sea-walls, built to repel the encroachments of the waves, and still scrupulously kept in repair, when perhaps the sea had retired from them many miles, and was encroaching on some different part of the coast.

There are multitudes, even as it is, who do not, even now, perceive the expediency of the omission; there are not a few who even complain of it as a defect, or even make it a ground of objection. That, in that day, the reasons for the procedure actually adopted, should have occurred, and occurred to *all* the first Christians, supposing them mere unassisted men, and men, too, brought up in Judaism, is utterly incredible.

But besides the reason we have now been speaking of, there is another, perhaps not less important, against the providing in Scripture of a regular systematic statement of christian doctrines. Supposing such a summary of Gospel truths had been drawn up, and could have been contrived with such exquisite skill as to be sufficient and well adapted for all, of every Age and Country, what would have been the probable result? It would have commanded the unhesitating assent of all Christians; who would, with deep veneration, have stored up the very words of it in their memory, without any need of laboriously searching the rest of the Scriptures, to ascertain its agreement with them; which is what we do (at least are evidently *called on* to do) with a *human* exposition of the faith: and the absence of this labour, together with the tranquil security as to the correctness of their belief which would have been thus generated, would have ended in a careless and contented apathy. There would have been no room for doubt,—no call for vigilant attention in the investigation of truth,—none of that effort of mind which is now requisite, in comparing one passage with another, and collecting instruction from the scattered, oblique, and incidental references to various doctrines in the existing Scriptures; and in consequence none of that excitement of the best feelings, and that improvement of the heart, which are the natural, and doubtless the designed result of an humble, diligent, and sincere study of the christian Scriptures.

In fact, all study, properly so called, of the rest of Scripture,—all lively interest in its perusal,—would have been nearly superseded by such an inspired compendium of doctrine; to which alone, as far the most convenient for that purpose, habitual reference would have been made in any questions that might arise. Both would have been regarded, indeed, as of divine authority; but the Compendium, as the fused and purified metal: the other, as the mine containing the crude ore. And the Compendium itself, being not like the existing Scriptures, that *from which* the faith is to be learned, but *the very thing to be learned,* would have come to be regarded by most with an indolent, unthinking veneration, which would have exercised little or no influence on the character.

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[1] Bishop HIND'S *History of the Rise and Progress of Christianity,* vol. ii., p. 113–115.

Their orthodoxy would have been, as it were, petrified, like the bodies of those animals we read of incrusted in the ice of the polar regions; firm-fixed, indeed, and preserved unchangeable, but cold, motionless, lifeless.

It is only when our energies are roused, and our faculties exercised, and our attention kept awake, by an ardent pursuit of truth, and anxious watchfulness against error,—when, in short, we feel ourselves to be doing something towards acquiring, or retaining, or improving our knowledge,—it is then only, that that knowledge makes the requisite practical impression on the heart and on the conduct.

To the Church, then, has her all-wise Founder left the office of *teaching*, to the Scriptures, that of *proving*, the christian doctrines: to the Scriptures He has left the delineation of christian *principles;* to each Church, the *application* of those principles, in their Symbols, or Articles of Religion,—in their Forms of Worship,—and in their Ecclesiastical regulations.

And there can be no doubt that every Christian is bound, in duty to his divine Master, to pay obedience to the enactments and ordinances —not adverse to Scripture—of the Church he belongs to, though consisting of uninspired men. For such a measure of obedience is indispensably necessary for the existence of *any* SOCIETY. And it is certain that it is the will of the Lord Jesus that his People *should* be members of those Christian Societies called Churches. . . . .

The religion He introduced was manifestly designed by Him—and so understood by His immediate followers—to be a *social* religion. It was not merely a revelation of certain truths to be received, and of practical rules to be observed, —it was not a mere system of doctrines and precepts to be embraced by each individual, independently of others; and in which his agreement or co-operation with any others would be accidental; as when several men have come to the same conclusion in some science, or have adopted the same system of agriculture or of medicine; but it was to be a *combination* of men who should be "members of the body of Christ,"—"living stones" of one spiritual temple; "edifying" (*i.e.* building up) "one another in their faith,"—and "brethren" of one holy family.

Of this design to establish what should be emphatically a social religion,—a "fellowship" or "communion (*i. e.* community) of saints," there can be, we should think, no doubt in the mind of any reflecting reader of our Sacred Books. Besides our Lord's general promise of "coming unto and dwelling in *any man* who should love Him, and keep his saying," there is a distinct promise also of an especial presence in any *assembly*—even "of two or three—gathered together in his name." Besides the general promises made to prayer,—to the prayer of an individual "in the closet,"—there is a distinct promise also to those who shall "*agree together*, touching something they shall ask." And it is in conformity with his own institutions that Christians have, ever since, celebrated what they designate as, emphatically, *the Communion*, by meeting together, "to break bread," in commemoration of his redemption of his people.

His design, in short, manifestly was to adapt his religion to the *social* principles of man's nature; to bind his disciples, throughout all ages, to each other, by those ties of mutual attachment, sympathy, and co-operation, which in every human community and association, of whatever kind, are found so powerful.

And it is evident that whoever directs or sanctions the establishment of a Community, must be understood as thereby sanctioning those institutions which belong to the essence of a Community.

Now there are three things which necessarily pertain to every Community or Society, and are implied by its existence; 1st, *Officers;* 2dly, *Rules;* and, 3dly, the power of admitting or excluding *Members*.

I. Whatever may be the character and objects of any Society—whether it be a political Society [or State,]—or a scientific,—or a mercantile,—or a religious society, such as we call a *Church*,—in all cases, it must have some kind of Government, and consequently, certain Officers to administer that Government; to manage the affairs of the Body, and to exercise some control over the individual members of it.

II. There must also be, in every society, some kind of *Rules;* whether called Laws, or Statutes, or Canons, or by whatever other name: and these rules must be enforced by some kind of *Penalties* against violations of them.

III. And there must also exist, somewhere, a power of determining who shall be *members* of the Society;—what persons shall be admitted or refused admittance into it, or expelled, or restored.

These three things are, as we have said, essential to *every* kind of Society.

As for a Civil Community [or State,] *that* is not a *voluntary* society; but must have, from the very nature of the case, a *coercive* power: it is necessary that all persons residing in each Country, should be *compelled* to submit to the government of that country. And there is no *limit*, except in the justice and wisdom of the rulers, to the punishments denounced against those who disobey the laws.

But in a *voluntary* Society, (such as Christ designed a Church to be,) the ultimate penalty must be expulsion, all others short of this being submitted to as the alternative. "If he refuse," says our Lord, "to hear the Church; let him be unto thee as a heathen man,"—that is, no longer a member of that church.[1]

And even as a "heathen man,"—one who never belonged to our Society,—has no claim to any of its privileges, nor is subject to its government, or liable to its penalties; so, if one who *has* been a member of it, has renounced its authority, or has been formally expelled from it, he is placed on the same footing. It would be unfair, on the one hand, *for him* to claim any of its advantages, or, on the other hand, for *us* to attempt to subject him to its laws and its penalties. He, and that particular Society, have thenceforth nothing to do with each other.[2]

And here it should be observed that it is necessary not only that every Community should *have* laws, enforced by certain penalties, but also that it should have power to *make* laws, from time to time, not in opposition to the fundamental principles of the society, but for the carrying out of those principles.

For it would be impossible to lay down rules, once for all, so minute and precise as to meet every possible case, and never to need any addition. Even the Mosaic law, which was extremely particular in its directions, was not sufficient without some enactments, made by competent authority, to decide, for instance, what was or was not to be accounted *work*, and consequently prohibited on the Sabbath-day; and many other such points of detail.

Our Lord does indeed censure the Jewish rulers for having, in some points, made absurd and frivolous regulations: and in some, having "made the word of God of none effect, through their tradition." In the one case, they had made an *ill use* of the power intrusted to them; in the other they had altogether *exceeded* their power. But nevertheless, He acknowledges that the power did exist in the rulers of the Jewish Church, and that obedience was due to it when their enactments were not at variance with God's laws. "The scribes and Pharisees" said He, "sit in Moses' seat;" that is, they are his successors in the office of making and enforcing regulations for the Jewish church; "whatsoever *they bid you* observe and do, *so do ye;* but do ye not after their works; for they say, and do not."

Now the rules laid down in Scripture for a Christian Church, are (as was remarked above) far less numerous and less precise than those of the Law. So that it was even much more necessary that a christian Church should have that power which our Lord himself acknowledged to have been possessed by the Scribes and Pharisees.

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[1] That is, of that particular church whose authority he has renounced. It does not follow that he may not be a member of some other church.

Indeed, it has often happened, amidst the many unhappy dissensions among Christians, that *all* the members of a church that is completely opposed to another, are shut out from christian inter-communion with the other church.

But though we may be justified in saying, such and such a person is not, and cannot be, considered a member of *this* particular church, we have no right to pronounce him thereupon excluded from the Universal Church of Christ.

[2] Sometimes it has happened that some church, though claiming no power over a "heathen man," has yet called in what is termed the "secular arm," to punish as heretics, persons who have renounced allegiance to that church, or whom it has excommunicated. But this is in manifest opposition to what our Lord says in the passage above referred to, as well as to his declaration that his "kingdom is not of this world."

Whether those persons were justly or unjustly excommunicated,—or whether they were right or wrong in seceding,—the church which has renounced them, or which they have renounced, has clearly no more rights over them, according to our Lord's express declaration, than it has over a "heathen man."

And since it was undoubtedly his design that there should always be christian churches "even to the end of the world," there can be no doubt that He intended these churches to possess all those three requisites above mentioned, without which no community of any kind can subsist. And hence, we may feel assured that the officers of christian churches, and the rules established in them, (when not adverse to Gospel principles), and the penalties which form the sanction of those rules, and the power which every church exercises of admitting or excluding persons as *members*,—all these, must, we are sure, have the sanction of our divine Master Himself.

All this we might infer, as has been said, from the mere fact of his having sanctioned the formation of christian communities. But, besides this, He expressly conferred on his Apostles—the first founders and first rulers of christian churches—those very powers just mentioned.

The power of "binding and loosing"[1]—that is, of making and annulling decisions and regulations—He distinctly conferred on the Apostles; declaring that their decisions should be bound "in heaven," that is sanctioned by Himself. (Matt. xvi. 19.)

This declaration He made first to Peter, as being the person chosen to take the lead in laying the first foundation of a christian church; both among the Jews on the day of Pentecost, and afterwards among the Gentiles. (Acts ii., x.) But subsequently, a little before his departure, He appoints a kingdom to the Apostles generally. (Luke xxii. 29.) In addressing Peter, He mentions the "keys of the kingdom of heaven," that is the power of admitting members into the christian church, and of excluding them. But this is in fact included in the appointment to the kingdom; since the rulers of a church must be intrusted with this power.

And He also expressly conferred on the Apostles the power of inflicting and remitting church penalties (John xx. 23), for offences against the society,—what we call *Ecclesiastical* offences. And it is likely, that, besides this, his words had reference also to their office of preaching "baptism for remission of sins," and of administering or refusing baptism, according as each person might appear in their judgment fit or unfit: that is, the qualifications for being admitted into Christ's kingdom, and for being allowed to continue a subject of it, having been laid down by Himself as the Supreme Head, his ministers were left to decide in each case, who was, or was not, thus qualified.

This, doubtless, was our Lord's meaning when He spoke of the "keys of the kingdom of heaven." And it is probably one part of what He meant to include in the power of remitting and retaining sins.

But this, at least, is quite certain, that no mere man can have power to forgive sins *as against* GOD; or to grant or refuse admission into the realms of heavenly bliss; which is the office of the Lord Jesus Himself at the Day of Judgment. By Him his disciples were merely authorised to admit men into his kingdom on earth,—that is, his Church: and to pronounce not what *particular individuals*, but what *kind* of persons should have remission of sins against God, and should attain eternal life,—namely, those whose penitence and faith are seen by Him to be sincere.

He might, had He seen fit, have gifted his apostles and other ministers with the faculty of reading any man's heart, and foreseeing the future course of his life; and He might thus have enabled them to pronounce positively of an individual, that his sins were pardoned by the MOST HIGH, and that he would inherit eternal life. But this gift our Lord did not think fit to bestow on his Apostles, or on any man. They were left, to judge, as they could, of the sincerity of each man's professions, and of the steadfastness both of his faith, and of his whole christian character. And in this they were liable to be deceived; as is evident from the case (among others) of Simon the sorcerer (Acts viii.); for he would not have been admitted to baptism, if it had been perceived at the time that he was "in the bond of iniquity."

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[1] This is the phrase which was and still continues in use among the Jews in that sense.

But offences *against a society*, that society has a right to pardon; just as an individual may forgive sins against himself. Indeed, our Lord, we know, commanded us thus to forgive. But of course He did not mean that we have power to pardon sins as against God. For *that* belongs to Him alone. If any one does some wrong to us, or to a Society, he also, by doing this wrong, sins against God. It rests with us, or with the society he has wronged, to pardon the *wrong as against his fellow-men.* But God alone can pardon the sin against God.

All those three requisites, then, which we have been speaking of as essential to every Society, our Lord expressly established. He appointed *officers*, and He conferred the power of enacting *rules*, and of admitting and excluding *members.*

And it is plain that what He said to those particular disciples He was addressing, could not be meant as limited to them alone, but as having reference to His Church "even unto the end of the world;" since it is certain He designed his Church not to cease with the lives of its first founders, but to continue permanently.

We may, perhaps, think that, if matters had been left to our judgment and disposal, we should have asked for a continuance of miracles for the conversion of unbelievers, and a continued inspiration in the church, in order to be sure of an infallible interpretation of Scripture. But as there is no promise of anything of this kind, we have no right either to conclude from our own wishes, that it must exist; or again, to reject Christianity for not completely answering our wishes. It is quite otherwise, however, with those things we have been speaking of as *essential* requisites for a Society. We infer that a christian church must have them, not because this is *advantageous* and desirable, but because it is *indispensable* to every kind of Society. Without Officers and Rules of some kind or other, and power of enrolling and excluding Members, no society could subsist at all. And since our Great Master did sanction the existence of christian societies, we fairly conclude, that by so doing, He sanctioned whatever is essential to the existence of a society, and implied thereby.

Such was manifestly the will of the divine Founder of our religion. And it was also his will that christian communities, the several portions of his kingdom, should continue to subsist under the government of *uninspired* fallible men, having no miraculous powers, nor any infallible guide on earth to appeal to, in case of any doubt as to the right interpretation of Scripture, or the right application of scripture principles.

This may seem to some persons very strange. Not but that we can perceive plainly that there is a *difference* between our case and that of those who lived when the Gospel was first proclaimed. For in order to *introduce* a revelation from Heaven, it was indispensably necessary that certain persons should receive from Heaven a communication of what that revelation was. And no one could have been expected to listen to them, if they had not proved, by the display of miraculous powers, that they really had received such a communication. In after times, on the contrary, the *writings* of those persons may be referred to for a knowledge of what the religion is. And the miracles by which *they* established it, and without which it never *could* have been established, may be appealed to in proof of its divine origin.

But still, if it were left to each Christian's judgment and choice, whether he would or would not have inspiration and other miraculous gifts bestowed on the Church, for the conversion of unbelievers, and for the satisfaction of the doubting, and for the correction of such errors as arise from time to time,—if each man were left to decide on this according to his own judgment and wishes—it is probable that very many would ask for a restoration of those gifts. We should not at least find all Christians agreeing to decline them as no longer needed.

Many there are who would fain have—somewhere at least on earth—an infallible guide, accessible to all men, to decide, by evident divine authority, on any questions that may arise. And some there are who are even so bent on this, that they resolve to find it, because they deem it needful, with, or without good reasons for believing it to exist; and who will accept the Gospel on no other condition.

The truth is, that there is in the human mind a craving for infallibility, which predisposes men towards the pretensions, either of a supposed unerring church, or of those who claim or who promise immediate inspiration. And accordingly, we find persons sometimes waver for a time between these two classes of pretensions, and ultimately give in to the one, or to the other, and sometimes thus changing more than once, yet still always clinging to the confident expectation of finding that infallibility we have been speaking of. They are inquiring only after a way of exempting themselves from all further inquiry. Their *care* is only to relieve themselves ultimately from all further need of vigilant care. They are navigating in search of a perfectly safe haven, in which the helm may be abandoned, and the vessel left to ride securely, without any need of watching the winds and currents, and of looking out for rocks and shoals. They hope to obtain, in all ages of the church, that exemption from all need of vigilant circumspection, which was not granted even in the age of the Apostles; since we find that, even when there *were* these infallible guides on earth, Christians are perpetually warned of the danger of mistaking "false apostles" for genuine.

And it may be added, that any one who is thus induced to give himself up implicitly to the guidance of such a supposed infallible authority, without presuming thenceforth to exercise his own judgment on any point relative to religion, or to think for himself at all on such matters,—such a one will be likely to regard this procedure as the very perfection of pious *humility*,—as a most reverent observance of the rule of "lean not to thine own understanding;" though, in reality, it is the very error of leaning improperly to our own understanding. For to resolve to believe that God *must* have dealt with mankind just in the way that *we* could *wish* as the most *desirable*, and in the way that to *us* seems the most *probable;* this is in fact to *set up ourselves as his judges.* It is to dictate to Him in the spirit of Naaman, who *thought* that the prophet would recover him by a touch, and who *chose* to be healed by the waters of Abana and Pharpar, the rivers of Damascus, which he deemed better than all the waters of Israel.

But any thing that falls in at once with men's *wishes*, and with their *conjectures*, and which also presents itself to them in the guise of a *virtuous humility;* this, they are often found readily and firmly to believe, not only *without* evidence, but *against* all evidence. And thus it is in the present case. The principle of which we have been speaking,—that every revelation from heaven necessarily requires, as an indispensable accompaniment, an infallible interpreter always at hand,—this principle clings so strongly to the minds of many men, that they are even found still to maintain it, after they have ceased to believe in any revelation at all, or even in the existence of a God.

There can be, we conceive, no doubt of the fact, that very great numbers of men are to be found,—they are much more numerous in some parts of the Continent than among us;—men not deficient in intelligence, nor altogether strangers to reflection, who, while they for the most part conform externally to the prevailing religion, are inwardly utter unbelievers in Christianity; yet still hold to the principle,—which, in fact, has had the chief share in *making* them unbelievers,—that the idea of a DIVINE REVELATION implies that of a universally-accessible INFALLIBLE INTERPRETER; and that the one, without the other, is an absurdity and contradiction.

We have said that it is this principle that has mainly contributed to make these men unbelievers. For when a tolerably intelligent and reflective man has fully satisfied himself, that, in point of fact, no such provision *has* been made,—that no infallible and universally-accessible interpreter does exist on earth—yet still adheres to the principle of its supposed *necessity*, the consequence is inevitable, that he will at once reject all belief of Christianity. The ideas of a REVELATION, and of an unerring INTERPRETER, being in his mind inseparably conjoined, the overthrow of the one belief cannot but carry the other along with it. Such a person, therefore, will be apt to think it not worth while to examine the reasons in favour of any other system of Christianity *not* pretending to furnish an infallible interpreter. This—which, he is fully convinced, is essential to a revelation from Heaven—is by some churches *claimed*, but not *established*, while the rest do not even claim it. The pretensions of the one he has listened to and deliberately rejected; those of the other he regards as not even worth listening to.

The system, then, of reasoning from our own conjectures as to the necessity of the Most High doing so and so, tends to lead a man to proceed from the rejection of his own form of Christianity, to a rejection of revelation altogether. But does it stop here? Does not the same system lead naturally to Atheism also? Experience shows that that consequence, which reason might have anticipated, does often actually take place. He who gives the reins to his own conjectures as to what is *necessary*, and thence draws his conclusions, will be likely to find a *necessity* for such divine interference in the affairs of the world as does not in fact take place. He will deem it no less than necessary, that an omnipotent, and all-wise, and beneficent Being should interfere to rescue the oppressed from the oppressor,—the corrupted from the corrupter,—to deliver men from such temptations to evil as it is morally impossible they should withstand;—and, in short, to banish *evil* from the universe. And, since this is not done, he draws the inference that there cannot possibly be a God, and that to believe otherwise is a gross absurdity. Such a belief he may, indeed, consider as useful for keeping up a wholesome awe in the minds of the vulgar; and for their sakes he may outwardly profess Christianity also; even as the heathen philosophers of old endeavoured to keep up the popular superstitions: but a real belief he will regard as something impossible to an intelligent and reflective mind.

We are very far from saying that all, or the greater part, of those who maintain the principle we are speaking of, are Atheists. We all know how common it is for men to fail of carrying out some principle (whether good or bad) which they have adopted;—how common, to maintain the premises, and not perceive the conclusion to which they lead. But the *tendency* of the *principle* itself is what we are speaking of: and the danger is anything but imaginary of its leading, in fact as it does naturally and consistently, to Atheism as its ultimate result.

But whatever our wishes or conjectures might have been, no such choice,—no such offer of infallible guidance—has been set before us. What is required of us is, thankfully to endeavour to make the best use of the advantages we *have*, instead of conjecturing or wondering why it is that we have not more. We are not called on to explain to the satisfaction of all men, or of ourselves, the reasons, in each instance, for God's having dealt with us as He has. What we are to say, in reference to any such inquiries, is, "Even so, Father! for *so it seemed good in Thy sight*."

To Him, then, it seemed good, that after the departure of the Apostles, no successors to them in the Apostolic office should arise. As *members* indeed, and as *ministers and rulers* of christian churches, they were succeeded by others, down to this day. But as *Apostles of Jesus Christ*, they have no successors. As personal attendants on Him, and eye-witnesses of his *resurrection*—as both possessors and *dispensers* of *miraculous* gifts (Acts viii. 14), and as *inspired oracles* to make known the divine will,—in all these points, which were what constituted the apostolic office, they left none to succeed them. In all that relates to christian churches, and also in that for the sake of which churches were instituted, the conduct of individual Christians in *all* the concerns of life,—men are now, by the decree of Providence, left to act (according to their own best discretion) in conformity with Gospel *principles*, as recorded in Scripture.

The Holy Spirit, indeed, "who helpeth our infirmities," is promised to those who earnestly seek it, and who strive to profit by it. This aid is needed by us, and is promised to us, both for the establishment of our *faith*, and also for the guidance of our judgment, and of our *conduct*, whether in matters connected with the Church, or in anything else. But how far any one is really "led by the Spirit" in each instance, there is no authority on earth to decide. It is the office of that Spirit to guard us both from *error* and from *sin*. But we must not pretend to be either free from sin, or exempt from error; since of *that* we cannot be infallible judges. If it be right to say, "Who can tell how oft he offendeth?" we ought to add also, "Who can tell how oft he mistaketh?"

A christian church, then, being a Society, instituted under Christ's sanction, for the purpose of keeping up and extending the knowledge and practice of his religion, and of thus making men faithful and obedient subjects of his kingdom, the rulers of such a Society are bound to act, according to the best of their power, with a view to this object. They are to keep in mind, that is, that it is *Christ's* kingdom and not their *own*, in which they hold office. "We preach not ourselves," says the Apostle, "but Christ Jesus our Lord; and us, your servants for Christ's sake."

The powers, therefore, which He has entrusted to a Church are to be exercised in strict conformity with the principles laid down by Him and his inspired servants.

No Church has power to alter, or to add to, the terms of gospel salvation as laid down in Scripture; or to keep back from its members anything revealed in Scripture; or to encourage, or willingly leave them, in ignorance of it. For its very office is, in the words of Christ Himself, to "teach them to observe *all* things whatsoever I have commanded."

It is, indeed, allowable, and proper, that a Church should employ, for the instruction of its people, convenient Summaries and Expositions of Scripture doctrine, such, for instance, as Catechisms. For this is to supply an omission, which (as above observed) was purposely left in Scripture. But then these Catechisms, &c., must contain the very doctrines of Scripture, and none other. And being the compositions of uninspired men, no authority must be claimed for them, except from their agreement with Scripture. And the same rule applies to Forms of prayer and to Creeds.

Creeds, which have been sometimes called "Symbols," sometimes "Confessions of Faith," or "Articles of Religion," are statements of such doctrines as must be acknowledged by any one who would become, or remain, a member of the Church which adopts that Creed. In different Churches, in the earliest times, different Creeds were in use; and alterations were made in them from time to time. Not that any Church had a right to alter the christian Faith; but that it was necessary to meet, and guard against the particular religious errors which arose in various Ages and Countries. But as none of these creeds is to be found in Scripture, so, there is none that can claim any authority, except from its conformity to Scripture.

The *doctrines*, then, which a christian Church teaches, and is bound to teach, are to be those of the christian Scriptures; neither more nor less.

But on the other hand, Church *ordinances* and *regulations* are only required to be not *at variance* with Scripture. For it is indispensably necessary for a Church to make enactments on many points respecting which nothing is precisely laid down in Scripture; but only the general principle, "let all things be done to edifying."

For instance, assembling for public joint Worship is enjoined in Scripture; but the times, places and mode of conducting the worship are not specified. The Sacraments, again, as instituted by Christ, are to be celebrated; but the mode of celebration is not prescribed. It is not even ordered that the Elders [Clergy] are to administer the Sacraments; though this, (very naturally and properly,) has been the rule of every Church.

In these, and in several other points, a Church is not only authorized, but compelled, to make regulations; because we are enjoined to do things which *must* be done in *some* regular specified mode, and the mode is not laid down in Scripture.

For instance, since Christians are commanded (as has just been observed) to *assemble* (Heb. x. 25) for divine worship, it is necessary that the times for doing so should be fixed by authority. And, accordingly, certain days have been in all ages of Christianity, set apart by every Church, for this purpose. Thus every one knows what is called Christmas-day has been set apart to commemorate the birth of Jesus Christ; the day called Good Friday, for his crucifixion; and Easter-day in each year, and also the first day in each week (thence called "the Lord's Day"), to celebrate his resurrection.[1]

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[1] Hence, the Sunday, being (like the Jewish Sabbath) one day in every seven, is sometimes called the Christian Sabbath; though kept on a different day of the week from the Jewish Sabbath, and in a different manner, and to commemorate a different event.

Neither the fourth Commandment, nor any other law enjoining the observance of the seventh day of the week in memory of the close of the creation, is regarded by Christians as binding on them. For if it were, they would be bound strictly to obey it, as it was given. For the Apostles,—who, themselves, as Jews, kept the Sabbath-day, and also, as Christians, assembled for worship on the Lord's Day,—never made a *change* of the Sabbath from the seventh day to the first. And no Church, consisting of uninspired men, has any right to change any divine ordinance designed for them. But the Mosaic Law having come to an end, and, moreover, having never been binding on Gentiles, a christian church is left to determine what days shall be set apart, as above mentioned.

And in the observance of "the Lord's Day," after the example of the Apostles, (though no express command of theirs to that effect is recorded), all Churches, from the earliest times, have, very properly, agreed.

A Church that should act otherwise, would be *making an ill use* of the powers bestowed on it; but it would be presumptuously *exceeding* its powers, if it should dare to enact anything at variance with Scripture. For instance, either, on the one hand, to abolish the Sacraments ordained by Christ, or, on the other hand, to depart from that celebration of the Lord's Supper which He Himself appointed, and to administer the bread without the cup, which He directed *all* the Disciples to drink of, is what no Church can have any right to do.

And it would be equally against Scripture, and that in a most important point, to attempt to convert christian Ministers into *sacrificing* Priests: because Scripture plainly teaches that, under the Gospel, this office belongs to Christ alone.

But christian Ministers for the performance of such duties as are described in Paul's Epistles to Timothy and to Titus, and elsewhere, every church clearly has a right to appoint, for the reasons already given. And there is no reason to doubt that the Elders ordained in each Church by Paul, or any other Apostle, did themselves, in turn, ordain others to assist or to succeed them; and these again, others; and so on in perpetuity, down to the present day.

But then, it is from the Church that Ministers (as well as Church ordinances) derive all their authority. Whether in sending fresh labourers into the Lord's vineyard, or in any of their other functions, they must act as *authorised* by the Society, and as representing it; not as possessing independent powers, as individuals. For it is to a Church as to a Society that those rights we have been speaking of belong; and whatever is done by the regular Officers of a Society, conformably to its constitution, is to be considered as done by the society.

When, therefore, Bishops, or any others, are spoken of as *ordaining* persons to the Ministry, it must be understood that, being empowered by their Church so to do, according to the rules of that Church, they are its *representatives*, and their acts are its acts.

And if any Minister were regularly deprived of his office, he would no longer have any power either to ordain, or in any way to officiate; unless he were admitted into some other Church, and taken into its service as one of its Ministers.

The rights, then, conferred on christian Communities by our divine Master Himself, being such as we have described, no one need be distressed by doubts and fears respecting some possible irregularity in the ordination of some minister, which may possibly have occurred at some time or other, in the course of eighteen centuries.

Amidst the wars and tumults and general confusion which took place at various times during that space, and especially during what are called "the dark ages," when ignorance and barbarism, as well as lawless violence, were so prevalent, it may have happened, more than once, that some person who had never been regularly ordained, or, perhaps, even baptized, may have contrived to intrude himself into the ministerial office; and to have even attained the rank of a bishop; and may thus have been the ordainer of others, the successors of whom may possibly be among ourselves at this day.

There is no christian Minister now existing that can trace up, with complete certainty, his own ordination, through perfectly regular steps, to the times of the Apostles. And, accordingly, if the reality of the ministerial Office were made to depend, not on a man's being an acknowledged Minister of a christian Church, but on a certain mysterious sacramental virtue, transmitted from hand to hand, in unbroken succession from the Apostles, there would be a most distressing and incurable uncertainty in each Christian's mind, whether he were really baptized, really ordained, or really partaker of any christian privileges.

But as it is, there is no ground for any such perplexing doubts. A christian Community, formed on Gospel principles, confers on its recognised Officers the rights of christian Ministers; who are to be regarded as having Christ's commission, and as successors of the Apostles in the ministerial office. We are bound, indeed, to do our very best to prevent irregularities of any kind, in ordinations, and in every thing else connected with our religion. But we need not fear that any accidental or unavoidable irregularity that may ever have occurred, can have the effect of shutting out whole Bodies of sincere disciples from the Gospel covenant and christian ordinances, or from any privilege granted by Christ Himself to those who should be "gathered together in his name."

It is to be observed, however, that although no *one individual christian Minister* can, with complete certainty, trace his own succession in an unbroken chain from the Apostles, and prove that there was no flaw in any link, the case is different when we look to *the Clergy* generally. For there can be no reasonable doubt that *such an Order of men* did always exist, from the times of the Apostles, continuously, to this day. We may be as sure of this as we are that great numbers of the English nation are descendants of the Saxons, who settled in Britain in the fifth and sixth centuries, though there is probably no one man who could trace his descent from any of them. For, christian Ministers held office in the churches as immediate successors of others who held the same office, and who in like manner professed to be the immediate successors of others, &c., whose predecessors had been appointed by the Apostles themselves.

Now if, a century ago, or ten centuries ago, or at any other time, a number of men had arisen, claiming to be the immediate successors (as above described) of persons holding this office, when, in fact, *no such Order of men had ever been heard of*, such an absurd pretension would have been immediately exposed and derided.

There must always, therefore, have existed such an Order of men, from the time of those Apostles who professed to be eye-witnesses of the Resurrection, and to work sensible public miracles in proof of their divine commission. And, consequently, the christian Ministry is a standing *monument* to attest the *public proclamation* of those miraculous events at the very time when they are said to have occurred.

Now, at that time there must have been great numbers of persons able and willing to expose the imposture, had there been any.

And this argument for the truth of the Sacred History is quite independent of any particular *mode* of appointing christian Ministers. If, for instance, these had always been elected by the People, and had at once entered on their office without any ordination by other Ministers, still, if they were but appointed (in whatever mode) as immediate successors of persons holding the same office, the argument would be the same.

That mode, indeed, of admitting men into the Ministry which was practised by the Apostles (1 Tim. iv. 14, and v. 22) has, in fact, been retained in all ages of Christianity. But the argument we have now been considering is quite independent of this. It turns entirely on the mere fact of *the constant existence* of a certain Order of men.

And it is worth observing, that the LORD'S DAY is a monument of the same kind. It is kept all over the world, by different and even hostile Bodies of Christians, in memory of the Resurrection of Jesus Christ. And not only so,—for this alone would not be a decisive proof,—but it is observed by them as a day which has been *always* thus kept, from the very day when the Lord Jesus is recorded to have risen, and to have appeared to his Disciples. Now, if it had *not* been thus constantly kept, from the first, but the observance of it introduced in some later age, those among whom it was thus introduced would have been able to testify that they had never heard of such a festival before.

CORRUPTIONS OF CHRISTIANITY.

It was observed in the preceding Section, that if all things relating to the Christian Church had been ordered by Divine Providence in the way that *men* would have been likely to conjecture as the most probable, and to wish for as the most desirable, there would have been some infallible guide left on Earth, to decide all questions that might arise, and to guard us against all possible religious error. There would have been a *perpetual inspiration* lodged in some person or persons, indued with such manifest *miraculous* powers as could leave no doubt as to their inspiration. And these infallible interpreters would have been universally and readily *accessible.*

But it is notorious, that such was *not* the design of Providence: and that no such guide does exist. Of all the persons who have claimed infallibity, there is none who has displayed (as Paul did) "the signs of an apostle," that is, such palpable and undeniable miraculous powers, as to leave no doubt in any candid mind, of his being really inspired. And since the very purpose for which an infallible guide is supposed to be needed, is, the removal of all reasonable *doubts*, it is plain that if God had thought fit to provide us with such a guide, He would not have left it at all *doubtful* where we were to look for that guide.

It seems to have been his design that part of Man's trial on Earth should consist in his being required to "prove (Δοκιμάζειν), [that is, try and examine] all things, and hold fast that which is right." We are called on to inquire carefully, and humbly, and piously, after truth; and to embrace whatever appears, to the best of our judgment, to be the truth.

To complain of this,—to reject or undervalue the revelation God has bestowed, urging that it is no revelation to us, or an insufficient one, because unerring certainty is not bestowed also,—because we are required to exercise patient diligence and watchfulness, and candour, and humble self-distrust,—this would be as unreasonable as to disparage and neglect the bountiful gift of eyesight, because men's eyes have sometimes deceived them; because men have mistaken a picture for the object imitated, or a mirage of the desert for a lake; and have fancied they had the evidence of sight for the sun's motion; and to infer from all this that we ought to blindfold ourselves, and be led henceforth by some guide who pretends to be himself not liable to such deceptions.

The two great volumes,—that of Nature, and that of Revelation, which God has opened before us for our benefit, are in this respect analogous. Both are in themselves exempt from error; but they do not confer complete exemption from all possibility of error on the student of them. As the laws of nature are in themselves invariable, but yet are sometimes imperfectly known, and sometimes mistaken, by natural philosophers, so the Scriptures are intrinsically infallible, but do not impart infallibility to the student of them. Even by the most learned, they are in many parts imperfectly understood; by the "unlearned and unstable" they are liable to be "wrested to their own destruction."

But still, if no errors or dissensions had arisen in the Church during the days of the Apostles, and then, when these inspired teachers were removed, heresies and schisms (σχίσματα, divisions) had arisen for the first time, we might have felt as if God had forsaken us, and as if Christians were exposed to such trials as had not been originally designed. Or we might have imagined (as indeed some persons *have* imagined) that God would still grant us inspiration, attested by miraculous signs, if we were not wanting in faith, and in earnest supplication for such gifts.

And accordingly, in almost every Age of Christianity, there have been persons who have persuaded themselves that miraculous powers and inspiration actually are bestowed on themselves or on their Church; and these pretensions are believed by such as decide according to their own wishes and conjectures, without any rational proofs.

But when we come to examine Scripture History, we find that, even in the times of the Apostles, false teachers did "arise, speaking perverse things, to draw away disciples after them,"[1] and that Christians were thus divided into rival sects. And this, the Apostles teach us, is a part of the appointed trial to which we are to be subjected here on earth. "There must needs be heresies, that they which are approved may be made manifest" (1 Cor. xi. 19), that is, that men may have to exercise their care and candour in chusing between truth and error.

And since God did think fit that Christians should have to encounter such trials, He mercifully provided that they should be forewarned "to take heed to themselves." The errors and corruptions introduced, even in the days of the Apostles, are recorded in our Sacred Books, on purpose, no doubt, to put us on our guard; to prepare us to be watchful against corruptions of Christianity in all other Ages of the Church; and also to prevent our being disheartened at finding ourselves exposed to such a trial.

It is not the design of this Dissertation, nor indeed would its limits permit, to give an historical account of each of the various corruptions of Christianity which have taken place in different Ages and Countries. It will be sufficient to give a sketch of the principal *sources* from which they arose, and of the *means* by which, in many instances, they were encouraged and kept up.

These two general rules, then, are to be kept in mind:—

1*st*, That whatever *opposed* Christianity at the outset, afterwards tended to *mix* itself up with the Religion, and corrupt it.

2*dly*, That as far as any corruptions depended on *local* and *temporary* circumstances, so far, they would be likely soon to die away, without spreading widely; but so far as they were connected with *Human Nature*, we may expect to find them appearing again and again, in various Countries.

I. First, then, we have said that the causes which, at the beginning, led to open hostility against the Gospel, afterwards operated to corrupt it. All those human faults and follies—all those prejudices, and infirmities, and vices—which originally disposed men to reject the Christian religion, found their way *into* it, in proportion as it prevailed.

At first, almost all those whose notions and whose dispositions were wholly adverse to Christianity, rejected it altogether, and endeavoured to put it down: though even from the very first there were exceptions to this rule; as we see in the instances of Iscariot, and of Simon the Sorcerer. But as the Religion spread, and became less and less unpopular, and the number of disciples multiplied more and more, there was a continually increasing number of persons who, though members of Christian churches, had not fully understood the character of the Gospel, nor imbibed the spirit of it. And these introduced *into* the Religion the same kind of errors and wrong principles as had originally been openly arrayed *against* it.

The chief opposition to the Gospel arose from (1.) Judaism; (2.) Pagan Superstitions; (3.) Heathen Philosophy; (4.) Immorality of Character; and, (5.) Worldly Policy.

And the spirit of Judaism, of Paganism, &c., afterwards found their way *into* Christianity, and tended to corrupt it.

(1.) It has been pointed out in an earlier part of this Dissertation, how much opposed the prevailing Jewish notions and prejudices were to the religion of Jesus Christ.

And accordingly, one of the very earliest attempts to corrupt Christianity was made by the Judaizing teachers, who were continually endeavouring to bring the Gentile believers under the yoke of the Mosaic Law. (Acts xv., Gal. ii., Phil. iii.)

(2.) Then, again, of the opposition of the Pagan worshippers to the Gospel, we find many instances mentioned in the Book of the Acts of the Apostles; especially in chap. xvi. 20, 21; and xix. 27.

And we find, from time to time, attempts made to incorporate into Christianity superstitions borrowed from Paganism, or of a similar nature.

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[1] Acts xx. 28, *perverted* doctrines, *διεστραμμένα*.

The earliest, perhaps, of these corruptions of Christianity, was that introduced by those very ancient heretics the Gnostics, whom the Apostle John was particularly occupied in opposing, both in his Epistles and in the opening of his Gospel.

These men, it is well known, blended with christian doctrines many of the notions of the Pagans, of the Persian, and some other Eastern Nations. The religious system of these nations consisted in acknowledging and reverencing two Beings of equal power,—a good and an evil god,—whom they called Ormuzd and Ahriman. And some of their descendants, in the same regions, at this day, are said to retain this faith, and to be worshippers principally of the evil god.

The Gnostics accordingly taught, among other things, that the world was not created by the Supreme God, but by an Evil Being, or by a certain inferior god.[1]

But, as has been above said, various other Pagan errors, or errors resembling those of Paganism, have from time to time, crept into the christian Church.

(3.) The ancient heathen philosophers again, who believed little or nothing of the popular superstitions, were no less opposed to the Gospel, which they derided as "foolishness." And many of them, when they afterwards embraced Christianity, endeavoured to reconcile it with their philosophical speculations, and thus to be wise above that which is written.

It is evidently to this danger that Paul is alluding, in many passages; especially when he warns the Colossians, "Beware lest any man spoil you through philosophy and vain deceit, after the rudiments of the world, and not after Christ." (Col. ii. 8. See also 1 Cor. i. 20–28.)

It appears, therefore, that even in the Apostolic Age, men had begun to introduce into Christianity presumptuous speculations on matters not revealed in Scripture, and to make the Gospel a field for the exercise of their philosophical ingenuity. But in later ages this evil prevailed to a far greater degree.

(4.) As for moral depravity, no one can doubt how much this must have led many persons to shut their ears against the evidences for a religion which required them to reform their lives.

The description given of Felix, the Governor, would no doubt have suited a great number of others: "When Paul reasoned of righteousness, temperance, and the judgment to come, Felix trembled, and said, Go thy way for this time; when I have a convenient season I will call for thee."

But when persons of this character did become members of the Church, as it appears many did, even in the time of the Apostles, they naturally sought to accommodate the religion to their own corrupt characters. This seems to have been more particularly the case with those Gnostics above mentioned. For they taught that men are to be saved by what they called "knowledge[2] of the Gospel," while living the most immoral life, and yet having no sin (that is nothing imputed to *them* as sin) but being accounted righteous without "doing righteousness." (1 John iii.) And this it was that made the Apostle John so vehement in his censure of them.

But there are many allusions in the Apostolic Epistles, to others besides these Gnostics, who sought to "hold the truth in unrighteousness." (Romans i. 18.)

(5.) Lastly, *worldly policy* was evidently one of the chief causes which in the outset, acted as a hindrance to the reception of Christianity. It is plain, from the very nature of the case, that all views of worldly ambition,—all desire of worldly profit or advantage of any kind,—all considerations of supposed political expediency,—must have been, at first, arrayed in opposition to the Gospel. And every part of the sacred narrative confirms this. We find the Jewish rulers influenced by the fear that "the Romans would come and take away their place and nation." (John x. 48.) We find them urging before Pilate, that "whosoever maketh himself a king, speaketh against Cæsar." And we find the same sort of plea repeatedly used to the Roman governors, and often with effect. (See Acts xvii. 7, and xix. 23.)

And again, the poverty, hardships, and persecutions, which the early Christians had been so earnestly forewarned of by our Lord (John xvi. 1, 2), and to which they were actually exposed, must have operated very strongly in prejudicing all men of a worldly character against the religion.

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[1] Thence denominated by them Δημιουϱγός.

[2] Hence their title of "Gnostics;" that is, persons *knowing* the Gospel.

Of course, in proportion as Christianity became less unpopular, and more generally received, this cause would less and less operate in making men *reject* the religion, and would be more and more likely to *corrupt* it. In proportion as worldly-minded men became members of the Church, they would naturally endeavour to wrest the Religion to their own views of ambition or of profit.

This could not be expected to take place to the same extent in the earliest Ages as afterwards. Yet we find that even in the days of the Apostles, men had crept into the church who were tainted with avarice or worldly ambition, and who corrupted the christian doctrines so as to favour their own views. For we find Paul cautioning Timothy against "perverse disputings of men of corrupt minds and destitute of the truth, who regard religion as a source of profit."[1]

All the principal causes, then, which occasioned *opposition* to Christianity, at the outset, led afterwards to the *corruption* of the Religion; and accordingly, some of the principal corruptions which have, at various times, been introduced, will be noticed under the same five heads under which we have, just above, treated of the sources of the original opposition to the Gospel. Those causes, which had begun to operate even in the days of the Apostles, had, of course, more of this corrupting influence in later times. In proportion as the dangers to the Church from *without* were diminished, by the increasing prevalence of the Religion, the dangers from *within* naturally increased. For, the number must of course have become greater, of members of the Church who were such merely because they had been brought up as children of Christian parents, or because Christianity was the prevailing religion; and who *would* have rejected it when first preached, from their having an unconverted heart, and being strangers to the true spirit of the Gospel. And such persons will always be likely to aim at bringing their religion into a conformity with their own characters, instead of conforming their own characters to the Religion.

II. The second general rule we laid down was, that so far as any human fault or folly was peculiar to *some particular time or Country*, its effects may be expected soon to have passed away without spreading very far; but so far as it belonged to *human nature* in general, we must expect to find the evil effects of its reappearing again and again, in various forms, in all Ages, and in various regions.

And for the most part it will be found that the prejudices and evil dispositions of men which have introduced religious error, and accordingly the religious errors themselves thence arising, are different in their *outward form* according to the peculiar circumstances of each time and place; but that in *substance* and at bottom, they are nearly alike, always and everywhere.

For example, the prejudice of the Jews in favour of their own nation and institutions, gave rise to that very early heresy above noticed (see Acts xv., and Gal. ii.), of those who taught that all Christians were bound to keep the Mosaic Law; or at least, that such as did so had attained a superior degree of sanctity. The violation of the UNITY [ONENESS] of Christ's religion, by thus dividing Christians into two classes, admitted to different degrees of religious privilege, has been already noticed. The sect of Judaizing Christians, however, thus founded, seems not to have lasted long. The destruction of Jerusalem and its Temple appears to have soon put an end to it. But the *general* tendency towards this violation of Christian Unity, being not peculiar to the Jews, but a part of human nature, has shewn itself again and again, under various forms, in various portions of the Church.

What are called the "Monastic Orders," which have long existed in many Churches, are a striking instance of this. Though the great mass of Christians have been solemnly dedicated to Christ at baptism, wherein they engage to be his "faithful soldiers and servants;" yet many have thought fit to take on themselves a new and distinct engagement, not binding on Christians generally, but only on such as have professed this new and superior kind of Christianity. The members of such Orders are often called the "religious;" and there is one well-known order called the "Society of Jesus;" as if the Church itself were not the *Society of Jesus*, and all its members bound to be *religious*. And the members of these Orders are supposed to possess a certain extraordinary kind of holiness, from their imposing on themselves certain restrictions, and privations, and other sufferings, according to rules laid down, not by Scripture for all men, but by particular founders for their own Order. Now this is clearly in violation of the ONENESS of Christ's religion.

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[1] 1 Tim. vi. 5. Νομιζόντων πορισμὸν εἶναι τήν εὐσέβειαν·

Again, one may find persons dividing Christians into "Elect," and not Elect—those who are, and those who are not "God's people:" accounting some Christians "Saints," and others not; some "Evangelical" and others not. Though "Saints" was the very term used by the apostles to denote what we call "Christians;" and though it is plain that since *Christianity* is the religion of the "*Gospel*" [Evangelium], all doctrines and all persons must be *Evangelical* or not, exactly in the same sense, and in the same degree, that they are, or are not *Christian*.[1]

Those, also, who regard christian Ministers as *sacerdotal* Priests, acting as a kind of *mediators* between God and the People, are evidently going very far towards such a distinction between Clergy and Laity as is at variance with the Apostolical view of Christian-Unity.

And, it may be added, that there is a considerable number of persons who make a division of christians into the two classes, of Communicants and non-Communicants. For there are very many of these latter, who, though far from disregarding christian duty altogether, or absenting themselves from public worship, yet consider that, so far from being a duty, it would be a *wrong* thing for *them* to attend the Lord's Table, unless they were determined to become Saints in some peculiar manner, different from what is expected of christians generally. And this they think it would be presumptuous for *them* to pretend to. They regard themselves, in short, as an *inferior class* of christians.

And, it is to be observed, that the division of worshippers into different classes in respect of religious privileges, belonged, even much more, to the Pagan religions, than to the Jewish. For among the Pagans, certain persons were "initiated" into such "Mysteries" of their religion as were carefully kept *secret* from the vulgar. And this was not the case with the Mosaic religion.[2] The division, therefore, of Christians into such classes, is what the heathen converts, no less than the Jewish, would be inclined to. And it is, moreover, something so natural to man, that, in one shape or another, it has appeared in almost all parts and Ages of the Church.

And so it is with most of the other corruptions of Christianity. The particular *form* in which each has appeared, will have generally been determined by *local* and *temporary* circumstances; and, when these circumstances are changed, that particular corruption will die away, to reappear (so far as it pertains to the character of the "natural man,") under some new shapes, in various Countries.

It is to be observed, however, that those corruptions of Christianity which arise from the mixing up of Judaism with it, are, for one reason, likely to be more lasting than most others, and to be oftener revived. Christians acknowledge that the Mosaic Dispensation came from God. And that, and also the Christian Dispensation, are contained in the volume which we call the Bible. Now, any one who regards the Bible (which many Christians do) as *one book*, containing divine instructions, without having formed any clear notions of what does and does not belong to each Dispensation, will, of course, fall into the greatest confusion of thought. He will be like a man who should have received from his father, at various times, a great number of letters containing directions as to his conduct, from the time when he was a little child just able to read, till he was a grown man; and who should lay by these letters with care and reverence, but in a confused heap, and should take up any one of them at random, and read it without any reference to its *date*, whenever he needed his father's instructions how to act.

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[1] There are, indeed, some persons who confine both the terms "Christian" and "Evangelical" to those who exactly agree with them in all points, and belong to their Party; regarding all others as excluded from the Gospel covenant. But there are, again, some who make the distinction above alluded to.

[2] Josephus remarks, as a distinction between the Pagan and the Jewish religions, that this latter made known to all the People the mysteries of their religion, while the Pagans concealed from all but those specially "initiated" the mysteries of theirs.

Accordingly, many erroneous notions, wholly or partly drawn from Judaism, have again and again found their way into the christian Church.

For example, there have been in almost all Ages of the Church, persons who have taught that Jesus Christ is to come upon earth and reign in great worldly splendour at Jerusalem for a thousand years; which period is thence called Millenium. And superior privileges, as God's peculiar People, are then to be restored (according to this doctrine) to the Jews; that is, to such Jews as shall have continued *unbelievers;* not, to the descendants of those great multitudes of them who embraced Christianity in the days of the Apostles, and since, and who thereupon soon became blended with the Gentile Christians. But the remnant of the Jews who shall have obstinately rejected the Gospel up to that time, are then to be restored to their own land, and to have a superiority in God's sight over men of Gentile race. And the Temple at Jerusalem is to be restored, and to be again the place of peculiar holiness, whither all men are to resort to worship.

Now these expectations of a Christ, who is to be a great and victorious temporal king, and of a kingdom of earthly glory, and of the restoration of the Temple, and of the exaltation of the Jews above all other people, are precisely those which the Jewish nation were so wedded to when our Lord came, and which led most of them to reject Him.

There are several other religious errors which have arisen from the same cause,—the practice of confusedly blending together the Law and the Gospel. Thus, some persons, as we had before occasion to remark, represent temporal rewards and punishments as a part of the sanction of the Christian Dispensation; and again, future rewards and punishments as a part of the sanction of the Mosaic. And this, as we have already said, destroys all clear notions of either system, and leads to great and dangerous practical errors, besides exposing our Scriptures to unanswerable objections from infidels.

And again, the introduction into Christianity of sacerdotal Priests,[1] Altars, Sacrifices, and Temples, which is so utterly repugnant to the whole character of the Gospel, may be traced both to Judaism and to Paganism. For all these things were common to them both; though the Jewish Priests offered sacrifices to the true God, and the Pagan Priests to idols.

The Priests of the Israelites were appointed by the Almighty Himself, for the express purpose of offering *sacrifices*, in the name and on the behalf of the people; they alone were allowed to make oblations and burn incense before the Lord; it was through them that the People were to approach Him, that their service might be acceptable. A very great portion of the Jewish religion consisted in the performance of certain ceremonial rites, most of which could only be duly performed by the Priests, or through their mediation and assistance; they were to make *intercession* and *atonement* for offenders; they, in short, were the *mediators* between God and Man.

And among the Pagans, whose institutions appear to have been, in great measure, corrupt imitations of those of the Patriarchal religion, we find, in like manner, Priests, who were principally, if not exclusively, the offerers of sacrifices, in behalf of the State and of individuals,—intercessors, supplicating and making atonement for others,—mediators, as before, between Man and the object of his worship.

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[1] Our word "Priest" is formed from Πρεσβύτερος; which is, translated, an "Elder," in our version of the Bible. But the word which our translators have rendered "*Priest*" is, in the original Greek, Ἱερεὺς, in Latin, SACERDOS, and is always applied to a sacrificing minister. And the word is never applied to any one under the Christian dispensation, except Jesus Christ alone, our great and only High Priest, who offered up Himself a sacrifice for man's redemption.

Now we may be sure that, if the Apostles had ordained any one to the office of a *sacerdotal* priest, or had designed that there should be any such in the christian Church, there would have been mention made of it in the Book of Acts, and in the Apostolic Epistles.

Whenever the title of priest [Ἱερεὺς] is applied to any Christians, it is applied to *all* Christians (Rev. v. 10, and 1 Pet. ii. 9) as offering up themselves to God.

The office of priest, then, in that sense of the word which we are now considering, viz., as equivalent to 'Ιερεὺς, being such as has been described, it follows that in *our* religion, the *only* Priest, in that sense, is Jesus Christ Himself; to whom consequently, and to whom alone, under the Gospel, the title is applied by the inspired Writers. He alone has offered up an atoning *sacrifice* for us, even the sacrifice of his own blood; He "ever liveth to make *intercession* for us;" He is the "one *Mediator* between God and man;" "through Him we have access to the Father; and no man cometh unto the Father, but by Him."

As for the Ministers whom He, and his Apostles, and their successors, appointed, they are completely distinct from Priests in the former sense, in office, as well as in name. Of this office one principal part is, that it belongs to them (not exclusively indeed, but principally and especially) to preach the Gospel,—to instruct, exhort, admonish, and spiritually govern, Christ's flock. His command was to "go and teach all nations;" —to "preach the Gospel to every creature;" and these christian Ministers are called in the Epistle to the Hebrews, "those that bear rule over them, and watch for their souls, as they that must give an account." Now it is worthy of remark, that the office we are at present speaking of made no part of the especial duties of a Priest, in the other sense, such as those of the Jews, and of the Pagans. Among the former, it was not so much the family of Aaron, as the whole tribe of Levi, that seem to have been set aside for the purpose of *teaching* the Law; and even to these it was so far from being in any degree confined, that persons of any tribe might teach publicly in the synagogues on the Sabbath-day; as was done by our Lord Himself, who was of the tribe of Judah, and Paul, of the tribe of Benjamin, without any objection being raised; whereas an intrusion into the Priest's office would have been vehemently resented.

And as for the Pagan Priests, *their* business was rather to conceal, than to explain, the mysteries of their religion;—to keep the people in darkness, than to enlighten them. Accordingly the moral improvement of the people, among the ancients seems to have been considered as the proper care of the legislator; whose laws and system of public education generally had this object in view. To these and to the public disputations of philosophers, but not at all to the Priests of their religion, they appear to have looked for instruction in their duty.

That the Christian Ministry, on the contrary, was appointed in great measure, if not principally, for the purpose of giving religious instruction and admonition, is clearly proved both by the practice of the Apostles themselves, and by Paul's directions to Timothy and to Titus.

Another, and that a peculiar and exclusive office of the Christian Ministers, is, the administration of the Sacraments of Baptism and of the Lord's Supper. But this administration does not at all assimilate the Christian Priesthood to the Pagan, or the Jewish. The former of these rites is, in the first place, an admission into the visible Church; and therefore very suitably received at the hands of those whose especial business is to *instruct* and examine those who are candidates for baptism, as adults, or who have been baptised in their infancy; and in the second place, it is an admission to a participation in the gifts of the Spirit, which constitute the Church "the temple of the Holy Ghost." The treasury, as it were, of divine grace is then thrown open, to which we may resort when a sufficient maturity of years enables us to understand our wants, and we are inclined to apply for their relief. It is not, let it be observed, through the mediation of an earthly Priest that we are admitted to offer our supplications before God's mercy-seat; we are authorised, by virtue of this sacred rite, to appear as it were in his presence ourselves; needing no intercessor with the Father, but his Son Jesus Christ, both God and man. "Having therefore," says Paul, "*boldness* to enter into the holiest by the blood of Jesus, by a new and living way, which he hath consecrated for us, and having an High Priest over the house of God, let us draw near with a true heart, in full *assurance* of faith, having our hearts sprinkled from an evil conscience, and our bodies washed with pure water."

The Sacrament of the Lord's Supper, again, is not, as the Romanists unwarrantably pretend, a fresh sacrifice, but manifestly a celebration of the one already made. And the rite seems plainly to have been ordained for the express purpose (among others) of fixing our minds on the great and single oblation of Himself, made by the only High Priest "once for all;" that great High Priest who has no earthly successor. And *all* the communicants are alike partakers, spiritually, of the Body and Blood of Christ (*i. e.* of His Spirit), of which these are the emblems), provided *they themselves* are in a sanctified and right frame of mind. It is on the personal holiness of the Communicant, not of the Minister, that the efficacy of the sacrament depends; *he*, so far from offering any sacrifice himself, refers them to the sacrifice already made by another.

Such being, then, the respective offices of these two Orders of men (both now commonly called in English, "Priests," but originally distinguished by the names of *Hiereus* and *Presbyteros*), we may assert that the word in question is *ambiguous;* denoting, when thus applied to both, two things essentially distinct. It is not merely a comprehensive term, embracing two species under one class, but rather an equivocal term, applied, in different senses, to two things of different classes. At least, it must be admitted, that what is most essential to each respectively, is wanting in the other. The essential characteristic of the Jewish Priests, was (not their being *ministers* of religion; for that, in a certain sense, all the Levites were, but) their offering *sacrifices*, and making atonement and intercession for the people; whereas, of the Christian Minister, the especial office is religious instruction, and the administration of rites altogether different in their nature from the offering of sacrifices; totally precluding the idea of *his* being himself the mediator between God and Man.

And the contrast in this point, between the christian religion on the one hand, and all that exist, or ever existed, besides it (including the Jewish), on the other, will afford, if we rightly consider when, and by whom, our faith was introduced, one of the most powerful evidences of its truth.

The Apostles, though attentive to the regular government of the churches they founded, ordaining, for various services, Elders, and other Ministers, male and female, (the latter being known by the title of "Widows,") yet appointed no order of Priests in the sense of *Hiereus* (familiar as they must have been with the name), answering to the sacrificing Priests of the Jewish and of the Pagan religions. The same observation will apply to the Temple. The term was familiar to the New Testament writers; but it is never once applied by them to a christian place of worship; always to the worshippers themselves collectively;—to the christian congregation; as *e. g.* "Know ye not that ye are the temple of the Holy Ghost, which dwelleth in you?" "Your body is the temple of the Holy Ghost." "Ye, as lively stones, are builded together into an holy temple," &c.

All this is indeed perfectly intelligible to any one who understands the character of our religion. It is perfectly consistent with the Gospel scheme; but it is utterly at variance with the notions which would naturally have occurred to the unassisted mind of Man.

A further proof of this, if further could be needed, is furnished by the changes which were introduced in after ages. The very institution which Christianity in its pure state had abrogated, was grafted into it, as it became corrupted with human devices. An order of Priests in the ancient sense, offering pretended sacrifices, on a pretended altar, in behalf of the People, was introduced into the christian scheme, in such utter contradiction both to the spirit, and the very letter of it, that they were driven to declare the bread and wine of the Eucharist miraculously changed into literal flesh and blood offered up day by day repeatedly: although the founders of our religion had not only proclaimed the perfection of the one oblation of our Lord by Himself, but had even proved the imperfection of the Levitical sacrifices, from the very circumstance of their being repeated "year by year continually;" inasmuch as they would have *ceased*" (says the Apostle) "to be offered," if, like the sacrifice of Christ, "once for all," they could "have made the comers thereunto perfect." Now, if when the religion *had* actually been established *without Altar, without Sacrifice, without Priest on earth*, all these were introduced into it, in opposition to its manifest character, through the strong craving (if we may so speak) of "the natural man" after them; how much more might we expect—with what complete certainty—that men brought up Jews, and having never *seen or heard of* any religion, true or false, without Priests, would have instituted, had they been left to themselves, an order of sacrificing Priests in their new religion? And how certain, that, since they carefully abstained from this and provided against it in the terms they employed;—how certain—that they were *not* left to themselves, but proceeded under the guidance of a divine director?

The corruptions then subsequently introduced into Christian churches, in respect of the Priesthood, do in reality, by shewing what the tendency of *human nature* is, go to prove the *superhuman* origin of the original institution. These have, however, afforded ground for cavil against Christianity itself, to those who, ignorantly or designedly, confound the religion itself with this perversion of it.

The Greek and Romish, and some other Churches have, in fact, in some great degree, transformed the *Presbyteros*, the Priest of the Gospel Dispensation, into the *Hiereus*, or Levitical Priest: thus derogating from the honour of the ONE great High Priest, and altering some of the most characteristic features of his religion, into something more like Judaism or Paganism than Christianity.

To enter into the detail of this perversion, would lead to a discussion not only too long for our present purpose, but which in fact must have been forestalled by any one who is at all acquainted with the abuses formerly prevailing among us.

Before the Reformation of our Church, the Priest professed, like the Jewish, to offer sacrifice (the sacrifice of the Mass) to propitiate God towards himself and his congregation: the efficacy of that sacrifice was made to depend on sincerity and rectitude of intention, not in the Communicants themselves, but in the Priest; he assuming the character of a mediator and intercessor, prayed not *with* but *for* the people, in a tongue unknown to them, and in an inaudible voice; the whole style and character of the Service being evidently far different from what the Apostle must have intended, in commanding us to "pray for one another." The Priest undertook to reconcile transgressors with the Almighty, by prescribing penances, to be performed by them, in order to obtain *his* absolution; and, profanely copying our only High Priest, pretended to transfer to them his own merits, or those of the Saints. He, like a Pagan, rather than a Jewish, Priest, kept hidden from the people the volume of their faith, that they might, with ignorant reverence, submit to the dominion of error, instead of being "made free by the truth," which he was expressly commissioned to make known; thus hiding the "candle under a bushel," which was designed to "be a light to lighten the nations."

In short, whoever will minutely examine, with this view, the errors of our unreformed Church, will find that a very large and important portion of them may be comprehended under this one general censure, that they destroyed the true character of the Christian Priesthood, substituting for it, in great measure, what cannot be called a Priesthood, except in a different sense of the word. These errors, in short, go far towards changing the office of *Presbyteros* into that of *Hiereus*.

There is another point in which superstitions, very much like those of the Pagans, have corrupted the worship of many Christians. We had occasion to remark, in an earlier part of this Dissertation, that many of the Pagan gods were deceased MEN, whom they had deified on account of some supposed extraordinary excellence of character, and eminent services to mankind, or to their countrymen.

Some of these they worshipped as gods; others under the title of demi-gods, or heroes. Any man whom his countrymen had been accustomed to venerate very highly in his lifetime, they naturally first *wished*, and then *hoped*, and lastly *believed*, might be elevated after death to such an exalted state as to enable him to hear them, and to do them services, either by himself, or by making applications on their behalf to some superior god. And just as persons in humble life generally apply to a king or other great man, not directly, but through his ministers and other attendants, so, a large portion of the Pagan worship was addressed to some whom they accounted inferior gods.

But, moreover, they supposed each of these inferior deities to have a special regard for his own country. Thus Romulus (Quirinus) was the *tutelar* god of Rome, and Theseus of Athens, &c. And even private families had gods of their own, who among the Romans were called "Lares," and "Penates." And the superior gods also were supposed to have partialities for particular regions or races. Thus Minerva [Pallas] was tutelar goddess of Athens; and Diana [Artemis] of Ephesus; and Juno, of Argos and Samos, &c. The *power* also of many of their gods was supposed to be limited to particular places, or to particular offices. Thus, we find the Syrians fancying that the God of Israel was the God of the *hills* (1 Kings xx. 23), and would not be able to succour his People on the plains. And Castor and Pollux were supposed to protect sailors, &c.

And moreover, there were certain images and temples, which were supposed to have a superior sanctity above other images and temples of the same god. And again, some particular temples were resorted to by those who had need of some particular kind of service. Thus, oracles were supposed to be given by Apollo, not in every one of his temples, but only in those at Delos, and Delphi, and some others. And it was the like with respect to various other benefits sought for from several of the gods.

Such, then, being the natural tendency of mankind, the consequence was that many Christians, though they did not introduce into the christian Religion the worship of the *very same* gods which were worshipped by their pagan forefathers, yet fell into the same kind of superstitions.

Their deep reverence for the Blessed Virgin, and for the Apostles and other eminent Christians, led them to hope, and then to believe, that these persons were able after their departure from Earth, to hear any one who called on them, and to make prayers of intercession for them. And the evil of this practice of invoking departed Saints, was,—and still is, to many Christians—disguised by their overlooking the difference between asking the prayers of the *living* and of the departed. No doubt many persons entreated (as Simon the Sorcerer did, Acts viii.) Peter or other Apostles to pray for them. And James expressly exhorts Christians to pray for one another (Jas. i. 16). No Christian need scruple to ask any one whom he considers to be a pious and worthy man to pray for him. But when it came to be believed that a holy person, when *removed from the Earth*, can hear the addresses of thousands and millions of his votaries calling on him in all parts of the world, and know the secret dispositions of mind in each several person that invokes him, this belief did in fact *deify* him.

Whatever subtle explanations may be attempted of the way in which glorified "saints" are able to hear, from various regions, and to repeat, more prayers in the day than there are minutes in the twenty-four hours, it is plain that at least the great mass of their worshippers must regard them no less as gods than the ancient pagans did the Beings they worshipped.

The consequence was, that the chief part of the worship which is due to the "JEALOUS GOD" came to be paid to the Virgin Mary, and those other "Saints" (amounting to several hundreds), who were, from time to time, enrolled on the list.

And thus did Christians introduce into their Religion, under new names, almost every one of the ancient pagan superstitions just above noticed. They knelt before *images* and pictures of the saint they invoked. They attributed peculiar holiness to some particular image, or chapel, above others dedicated to the same saint. They had patron saints (answering to the tutelar gods of the Pagans) presiding over particular nations, or classes, or persons. One saint, again, was supposed to be peculiarly powerful in procuring some particular kind of relief or benefit; and another, in another kind. In short, we have only to look back to what has been just said of the Pagan worship, and we shall see how closely it corresponds in every point (besides many more which might have been added) with the worship which has been, in some Churches, introduced into Christianity.

And, on the other hand, if we look to the Scriptures, we shall plainly see that it is not *thence* that the invocation of Saints could have been derived. They not only contain nothing to warrant it, but they seem framed purposely to guard all who are sincerely desirous of following Scripture, against this very corruption. Though we find in the Book of Acts narratives of the death (Acts vii., xii.) of the two martyrs, Stephen, and James the Apostle, the brother of John, there is no mention of their being invoked after death. And when God saw fit to convey his commands to Cornelius, and again to Paul (Acts x., xxvii.) by a created Being, it is not either of these blessed martyrs, but an Angel, that is sent.

The Virgin Mary, again, is hardly so much as named throughout the Acts[1] and Apostolic Epistles. Now this silence respecting her is utterly inconceivable, supposing it had been the practice of the early Christians to pray to her. In the Gospels, again, she is but rarely mentioned.

Even John, her adopted son, though in all likelihood he must have long outlived her, does not record her death, nor give any particulars of her life; and yet he wrote, as is universally believed, purposely to supply the omissions of the other Evangelists. And it is remarkable that we gather from him *incidentally*, and only *incidentally*, that Mary had usually resided with Jesus, who, at his death, committed her to the care of the beloved Disciple; and "from that time he took her to his home." Why this sparing and unfrequent mention of her whom "all generations should call blessed," and who must have been personally so well known to many of the most eminent disciples?

Humanly speaking, this seems to us impossible. We are left,—we are driven, to suppose that the divine Spirit which guided the sacred Writers, led them, whether consciously or unconsciously, to suppress what they would naturally have recorded, in order to guard against that superstitious veneration for the Virgin Mary, to which, as experience shews, there is naturally so strong a tendency in the minds of Christians. And the few passages which do allude to her, furnish a strong confirmation of the soundness of this conclusion. They are chiefly such as are calculated, and apparently designed, to repress superstitious veneration. One of them records that, when the mother and other kindred of our Lord were announced as desiring to speak with Him, He took occasion to point out that these had no claim, on that ground, to especial reverence; He turned to his disciples, and said, "Behold my mother and my brethren!" Upon another occasion, when a woman exclaimed—"Blessed is the womb that bare Thee, and the paps that Thou has sucked"—He replied, "Yea, *rather* blessed are they that hear the word of God and keep it." One of those who *did* so, was, we may be sure, his mother herself; but the mere circumstance of her being *his mother*, did not, as He declares, imply a blessedness equal to that of the humblest of his faithful hearers. Does not the record of *these* allusions to one of whom so little is recorded, seem expressly designed to guard against that superstitious error to which the tendency is so natural, and, as experience has shewn, so strong?

Once more, it is mentioned in the narrative contained in the second chapter of St John's Gospel, that the mother of Jesus was invited, as well as himself, and his disciples, to the marriage-feast at Cana. She seems to have been apprised of his design to perform the miracle; for she applied to him when the wine was deficient. His answer has not that roughness, indeed, which our English translation gives it, from the use of the term "woman." The word in the original is one which denotes no disrespect; being found in the classical Greek writers applied even to a queen. But He plainly forbids her interference, telling her that the time is not yet come for the display of his miraculous power. Now, why is her application to him, and his reply,—why is even her presence on this occasion at all,—mentioned in this place? Evidently, for the purpose of shewing that he would *do no miracle at her bidding;* that his filial reverence did not extend to his admitting her interference in anything connected with his ministry. It is a warning to all who *will* be warned by Scripture, that they must not be led by their veneration for the mother of Jesus, to look for her intercession for them with her Son. "There is one mediator between God and Man," Jesus Christ—between Him and Man—none. He is himself ever at hand; and if any man will seek to do his will, "He will come unto him, and make his abode in him by his Spirit."

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[1] Once very slightly, in Acts i.

Any one, therefore, who carefully follows the teaching of the Evangelists and Apostles, will be preserved from such errors as we have been speaking of. But it was the disposition of "the Natural Man" that originally led the Pagans to corrupt the Religion revealed to the earliest generations, and to "worship the creature more than the Creator." And that very same disposition has led many of those Christians who neglect the guidance of Scripture, to introduce like corruptions into Christianity.

III. In addition to these sources of corruption, the tendency already mentioned to introduce philosophical speculations into Christianity has shewn itself again and again under various forms, in all ages of the Church, and has given rise to a multitude of heresies.

Philosophy is not at all opposed to true Religion, as long as men confine their speculations to matters which properly come within the province of Reason.[1]

But in what relates to Divine Revelations, Reason should be confined to these two points:—1*st*, To judge of the grounds on which any professed revelation should be received or rejected, as being "from Heaven, or of men;" and, 2*dly*, To determine what it is that we are enabled and required to learn from the Revelation which God has actually given.

The restless spirit of philosophising, however, was not easy to be subdued, or to be confined within these limits. Even during the times of the Apostles, and still more, after their departure, many philosophers, on embracing Christianity, transgressed their proper limits, and sought to exercise their ingenuity on that subject—one of so much interest and importance—in order to maintain their superiority over the vulgar, even in the knowledge of divine mysteries. They acknowledged, for the most part, that the christian revelation had made known things pertaining to God, which could not otherwise have been known: but these things they seem to have regarded as fresh *materials* for human reason to work upon; and when the illumination from heaven—the rays of revelation—failed to shed full light on the Gospel dispensation, they brought to the dial-plate the lamp of human philosophy.[2]

Accordingly, we find in very early times, curious questions raised concerning the incarnation, and the nature and person of the Lord Jesus. One system so ancient as to be alluded to by John in his Epistle, represented Jesus Christ as not really "come in the flesh," but as a man in appearance only. Other systems made *Jesus* to have been born a *mere human being*, on whom, at his baptism, a certain emanation (which they called *Christ*) from the divine fulness, descended and dwelt in Him. And endless were the questions raised, and the different hypotheses set up, as to the *manner* in which the divine nature was united with the human in Jesus Christ; whether He was properly to be called *one* person, or two; whether the Virgin Mary were properly to be styled the Mother of *God;* whether Christ should be regarded as of *one substance*, or of *like* substance with the Father; whether the Deity *suffered* at the crucifixion; in what way the sacrifice of Christ was accepted as a *satisfaction* for sin; *why* this sacrifice was *necessary;* besides (in later times) an infinite number of equally subtle speculations as to the nature of the Trinity,—the divine *decrees*,—and, in short, everything pertaining to the intrinsic nature of the Supreme Being, and the explanation of all his designs and proceedings. And yet the motions of the earth, and the circulation of the blood, were not discovered till many ages after. The cause of the vital warmth in animals, philosophers are not even yet agreed on; nor is it decided whether light, heat, and electricity, are substances, or qualities of bodies. But as to the *substance* of the Supreme Being, and of the human soul, many men were (and are still) confident in their opinions, and dogmatical in maintaining them; the more, inasmuch as in these subjects they could not be refuted by an appeal to experiment.

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[1] It is remarked by Locke, that those who are for laying aside the use of Reason in matters pertaining to Revelation, resemble one who should *put out his eyes* in order to make use of a *telescope*.

[2] Some persons have been so much struck with the resemblance between some of Plato's speculations, and those of certain ancient Theologians, respecting the Trinity, as even to imagine that he must have received some revelation from Heaven!

But instead of concluding that Plato had imparted to him by inspiration knowledge beyond what was communicated to the Apostles—or at least beyond what they were commissioned to teach—we ought rather to infer that those Theologians had corrupted the simplicity of the Gospel by mixing up with it Plato's philosophy.

All these various systems of philosophical theology were discussed in language containing technical terms more numerous than those of almost any science; some of them taken from the sacred Writers (we may say, in every sense of the phrase, "*taken from* them," since hardly any theologian confined himself to *their* use of the terms), and others not found in Scripture, but framed for each occasion. These were introduced professedly for the purpose of putting down heresies as they arose. That they did not effect this object, we know by *experience;* which, indeed, would lead us to conclude, that heresies were by this means rather multiplied. We are inclined to think, that if all Christians had always studied the Scriptures carefully and honestly, and relied on these more than on their own philosophical systems of divinity, the Incarnation, for instance, and the Trinity, would never have been *doubted*, nor ever *named.* And this at least is certain, that as scientific theories and technical phraseology gained ground, party animosity raged the more violently. The advocates of the several systems did not, like the ancient heathen philosophers, carry on a calm and friendly dispute, but (to the disgrace of the Christian name) reviled, and (when opportunity offered) persecuted each other, with the utmost bitterness. For each of them having not only placed the essence of Christianity in faith, but the essence of faith in the adoption of his own hypothesis, and strict adherence to his own use of the technical terms of his theology, was led hence to condemn all departures from his system, as involving both blasphemy against God, and danger to the souls of men. And they employed, accordingly, that violence in the cause of what they *believed* to be divine truth, which Jesus Himself and his Apostles expressly forbade in the cause of what *they knew* to be divine truth. "The servant of the Lord," says Paul, "must not strive, but be gentle unto all men, in meekness instructing them that oppose themselves, if God, peradventure, will give them repentance, to the acknowledging of the truth." (2 Tim. ii. 24, 25.) But those who lose sight of the real character and design of the Christian *revelation*, generally lose also the mild, patient, and forbearing *spirit* of the Gospel.

There is no one of the numberless systems we have alluded to that has not been opposed, and strongly condemned, by the advocates of some different one; but they have not usually been condemned on what appears to us to be the right ground.

The proper objection to the various philosophical systems of religion,—the different hypotheses or theories that have been introduced to *explain* the Christian Dispensation,—is, not the difficulties that have been urged (often with good reason) against *each* separately; but the fault that belongs to *all* of them equally. It is not that the Arian theory of the incarnation, for instance, is wrong for *this* reason, and the Nestorian for *that*, and the Eutychian for *another*, and so on; but they are *all* wrong alike, because they *are theories*, relative to matters on which it is vain, and absurd, and irreverent, to attempt forming *any* philosophical theories whatever.

And the same, we think, may be said of the various schemes (devised either by those Divines called the Schoolmen, or by others) on which it has been attempted, from time to time, to explain other religious mysteries also in the divine nature and dispensations. We would object, for instance, to the Pelagian theory, and to the Calvinistic theory, and the Arminian theory, and others, not for reasons *peculiar* to each one, but for such as apply in *common* to *all.*

Philosophical divines are continually prone to forget that the subjects on which they speculate, are, *confessedly*, and by their *own* account, beyond the reach of the human faculties. This is no reason, indeed, against our believing any thing clearly *revealed in Scripture;* but it *is* a reason against going beyond Scripture with metaphysical speculations of our own. One out of the many evils resulting from this, is, that they thus lay open Christianity to infidel objections, such as it would otherwise have been safe from. It is too late, when objections are alleged from the difficulties involved in some theory, to reply, that the whole subject is mysterious and above reason, and cannot be satisfactorily explained to our imperfect faculties. The objector may answer, "Then you should have *left* it in the original mysterious indistinctness of the Scriptures. *Your own explanations* of the doctrines of your Scriptures you must not be suffered to make use of as far as they are admitted, and then, when they are opposed, to shelter them from attack, as sacred mysteries. If we enter on the field of philosophical argument, we cannot be allowed afterwards to shrink back from fair discussion on philosophical principles."

It is wiser and safer, as well as more pious and humble, and more agreeable to Christian truth, to confess, that, of the mysteries which have been so boldly discussed by many who *acknowledge them to be unfathomable*, we know nothing beyond the faint and indistinct revelations of Scripture; and that if it had been possible, and proper, and designed, that we should know *more* of such matters, more would have been *there* revealed.

And we should rather point out to objectors that what *is* revealed, is *practical*, and not speculative:—that what the Scriptures are concerned with is, not the philosophy of the Human Mind in itself, nor yet the philosophy of the Divine Nature in itself, but (that which is properly *Religion*) the *relation* and connection of the two Beings;—what God is *to us*,—what He has done and will *do* for us,—and what *we* are to be and to do, in regard to Him.

How great must be the errors arising from men's overlooking, or not carefully attending to, this circumstance, it is hardly necessary to point out. The rustic, who persists in maintaining that the sun itself actually moves, because he sees it rise and set, *i.e.* sees that it is in different *positions relatively to himself;* and the child, who, while he is sailing in a ship, fancies that the land flies from him, or advances towards him; are not more completely mistaken in their notions, than those theologians who reason upon the accounts which the Scriptures give us of the Deity, as if these were intended to explain to us what He is, absolutely, in Himself, and not merely what He is in relation to ourselves.

And the liability to error is greatly increased by this circumstance; that even the relations in which God stands to his creatures are so imperfectly comprehensible by our understandings, that it is necessary to explain them by analogical language, and by the use of such types and comparisons, as may furnish to our minds a kind of picture or image of heavenly things, whose correspondence with the original cannot of course be in all points complete; any more than a picture can, in all respects, resemble the solid body which it is designed to imitate. If, therefore, we extend the analogy further than was intended, and conclude, that the things which are represented as corresponding in some points, must needs correspond throughout,—or if, again, we conclude, that the things must be *alike*, because they are analogous, and bear similar relations to something else,—we shall fall into the grossest absurdities; such as we often see in children, when they interpret literally the analogical explanations which are given them.

If any one will be at the pains to collect instances for himself, from recollection of his own infancy, and from what he has observed in other children, of the mistakes which are in this way continually committed by every child, and will carefully reflect on these, not as a mere source of amusement, but with a view to his own instruction, they will serve as a mirror to shew what sort of mistakes he himself also has to guard against, in the notions he forms respecting the Almighty.

To take one out of innumerable instances; how many there are who speak and reason concerning the *glory* of God (that being a phrase which occurs in Scripture), as if they supposed, that the desire of glory did literally influence the divine Mind, and as if God could really covet the admiration of his creatures: not considering that the only intention of this expression is to signify merely, that God's works are contrived in the same admirable manner, as if He *had* had this object in view: and that we are bound to pay Him the same reverent homage, and zealous obedience, as if He were really and literally capable of being glorified by us. And yet it is chiefly from a literal interpretation of this phrase of "the glory of God" that some Divines have undertaken to explain the whole system of divine

Providence, and to establish some very revolting and somewhat dangerous conclusions.

The difference between *Religious* knowledge properly so called, and what may be more properly styled theological *Philosophy*, may be thus illustrated. Different theories, we know, have prevailed at different times, to account for the motions of the planets, and of the moon, and other heavenly bodies,—the tides, and various other subjects pertaining to natural philosophy. Several of these theories, which supplanted one another, have now become obsolete; and modern discoveries have established, on good grounds, explanations of most of these points. But the great *mass of mankind* cannot be expected to understand these explanations. There are, however, many points of daily *practical* use, which they *can* understand, and which it is needful for them to be informed upon. Accordingly, there are printed Tables, showing the times of the sun's rising and setting at each period of the year,—the appearances of the moon,—the times of eclipses,—the variations of the tides, in different places, and the like. And all these are sufficiently intelligible, without any study of astronomy, even to plain unlearned men. The practical knowledge thus conveyed involves no astronomical theory, but may be equally reconciled with the Ptolemaic or the Copernican systems of the universe. It is not the less possible, nor the less useful, for any one to know the times when the sun gives light to this earth, even though he should not know whether it is the sun that moves, or the earth.

Now it is just such practical knowledge as this that the Scriptures give us of the christian Dispensation. They afford practical directions, but no theory. But there is this important difference between the two cases. The human faculties could, and at length did, (though it is beyond the great mass of mankind,) discover the true theory of the appearances and motions of the heavenly bodies. In matters pertaining to divine Revelation, on the contrary, though there must actually *be* a true theory, (since there must *be* reasons, and those known to God Himself, even if hidden from every *creature*, why He proceeded in this way rather than in that,) this theory never can be *known* to us; because the whole subject is so far above the human powers, that we must have remained, but for Revelation, in the darkest ignorance concerning it. Many curious and valuable truths has the world discovered by philosophy, (or as our translators express it "wisdom;") but "the world" (says Paul) "by wisdom knew not *God*:" of which assertion the writings of the ancient heathen philosophers, now extant, afford sufficient proofs.

And, we would further remark, that if it had been possible and allowable for us to follow up by metaphysical researches, the view opened to us by Revelation, and thus to enlarge our knowledge of God's dealings with Man, Paul (as well as the other Apostles) would not have censured, but favoured, such researches, and would have set us the example of so speculating. And if he *had* done this, even in those discourses of his which are not recorded in writing, we may be sure that his Gospel would *not* have been considered as "foolishness" by the Greeks, even those of them who did not fully agree with him. This, therefore, supplies a useful practical rule in judging of anything we may read or hear: whenever we meet with such a representation of Christianity as would *not* have been a stumbling-block to the Jews, or such as would not have been *foolishness* to the Greeks, we may at once conclude that *this cannot be the Gospel which Paul preached.* For he would not have been opposed as he was, had his doctrine favoured either men's pride and worldly ambition, or their spirit of presumptuous speculation.

It may be remarked, as another reason for condemning such presumptuous explanations, and metaphysical theories of Christianity, as we have alluded to,—all of them equally,—that if such speculations be allowed, it is evident Christianity must be, not one, but *two* religions;—that for the few profound theologians, and that for ordinary men; such as the humble shepherds to whom the holy Angels announced the birth of Jesus,—the fishermen and publicans who associated with Him,—and "the common people" who (we read) "heard Him gladly." Now there is nothing more characteristic of the Gospel Dispensation than its *oneness*;—*one* Lord,—one faith,—one hope,—in short, one and the same religion proposed to all who will heartily receive it.

All such speculations, then, we should reject, if we would (in the words of the Apostle Peter) "desire, as new born babes, the sincere (ἄδολον, *unadulterated*) milk of the Word, that we may grow thereby." If we would learn the very gospel which the Apostles taught, just as it was received by their hearers, we must in heart and spirit accompany the simple shepherds in their visit "to Bethlehem, to see" (not what human philosophy has devised, but) "what the LORD hath made known to us."

IV. Many corruptions, again, of Christianity have been either introduced, or favoured and kept up, by *moral corruption* in the members of christian Churches. For it belongs to the true Gospel to purify and also to elevate the moral character. Hence, there is a complete and constant opposition between genuine Christianity and all the evil and base propensities of man's nature. This is what Paul means when he says, "Walk in the Spirit, and ye shall not fulfil the lusts of the flesh; for the flesh lusteth against the Spirit, and the Spirit against the flesh; and these are contrary the one to the other, so that ye cannot do the things that ye would:" that is, he who has within him two contrary tendencies, cannot at the same time yield to both.[1]

Every kind of depravity or moral defect, therefore, predisposes men either to reject Christianity altogether, or else to introduce, or to accept, some erroneous views of it. And there is no kind of religious corruption against which men are usually less on their guard. They are well aware, indeed, that there is a danger of men's falling into sin in *violation* of the precepts of religion. And they are not ignorant that a religion which is altogether *false* may have a bad moral effect on the worshippers. But they consider that a man who has embraced a true Faith, and who is of a religious disposition, will necessarily be *made*, by his religion, a good moral man; or at least such a man as will be accepted as righteous by the God he worships.

Now, this is true, only if we suppose him to observe diligently the caution of Paul, "that they who have believed in God should be *careful* to maintain good works." (Tit. ii. 14, and iii. 8;) "giving all *diligence*," (2 Pet. i. 5) (as Peter exhorts us), to add to his faith, virtue, &c. But if he takes no vigilant *pains* in the improvement of his moral character, the result will be, that, instead of his religion improving his character, his moral deficiencies, on the contrary, will tend to corrupt his religion. The rain itself, which falls pure from the heavens, will not continue pure if it be received in an unclean vessel.

And this kind of corruption took place—as has been above said—even in the days of Paul; who speaks of some, "who having cast away a *good conscience*, concerning [the] Faith, have made shipwreck." (1 Tim. i. 19.)

It will be sufficient to mention some of the principal errors of this class, that have crept into the Church, without entering into a full examination of any of them.

1*st*, The notion that a Priest has power to forgive sins as against God is evidently a doctrine very acceptable to such persons as have a sense of religion, combined with a great dislike to the practice of christian virtue; and who, accordingly, are glad of any contrivance for being religious without virtue.

2*dly*, The same may be said of the doctrine, that fasting and other penances,—or pilgrimages to certain holy places,—or prayers and sacrifices offered up in behalf of the deceased,—or rich gifts bestowed on the Church, can atone for sin, and help to obtain for a man final salvation.[2]

3*dly*, Of a like nature is the doctrine, that if a man who has led a thoroughly unchristian life shall on his deathbed receive the Lord's Supper, or the rite of "Extreme Unction," professing sorrow for his sins, and faith in Christ, we are authorised to pronounce, that (supposing his professions to be, at the moment, sincere) his salvation is certain.

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[1] Ταῦτα δὲ ἀλλήλοις ἀντίκειται, ἵνα μὴ, ἃ ἂν θέλητε, ταῦτα ποιῆτε. Gal. v. 17. More exactly translated—"these are so opposed to each other as to be an obstacle to your doing what ye desire to do."

By the expressions which are rendered "flesh," and "fleshly lusts," and "a carnal mind, which is enmity against God," Paul does not mean merely *sensual* excess, but *all* evil dispositions of the natural man. For he expressly charges the Corinthians with being "carnal" on account of their "*strifes* and *divisions*."

[2] It is very remarkable that in all religions either devised by men, or corrupted by human inventions, there is a tendency to set aside certain particular *seasons*, or particular *persons*, for what is called "mortification,"—that is, *self-torture*, as a kind of set-off against the toleration of general licentiousness at other times, or in other persons.

Now, the utmost that Scripture can warrant, in such a case is, that we are not forbidden to *hope*. But the Scripture-*promises* are all made to those who "bring forth *fruits* meet for repentance." And any one who presumes to hold out confident promises where Scripture does not, is evidently guilty of preaching, not the true Gospel, but one of man's invention.

4*thly*, The heresy of the ancient Gnostic Antinomians has been already alluded to, as being held in such detestation by the Apostles. And some Antinomian doctrines much like theirs have been found in every Age of the Church.

For example, That because "by grace we are saved through faith, and that not of ourselves, but by the gift of God," (Eph. ii. 8,) and "without the works of the Law," therefore, we may safely "continue in sin that grace may abound," (Rom. vi. 7;) that certain persons may know and feel themselves set apart as "God's People," and that these are certain of salvation, though continuing in the practice of known sins, because God will not impute sin to *them*, do what they will; and that they ought not to be at all uneasy at any sins they may commit, because He purposely suffers "his own people to fall into very grievous sins, in order to show them their own weakness, and to *humble* them!" though in reality such a doctrine is calculated to puff up a man with spiritual *pride*, in addition to all his other vices; since nothing is more flattering to a proud heart than the notion of being *privileged* to do without censure, or without danger, what *others* would be condemned for.

All these shocking absurdities, so utterly at variance with Scripture, have found their way into Christianity through the depravity of Man. And when we consider, that besides the mischief done by such teachers to their own followers, they bring a scandal on Christianity itself, we cannot wonder at the abhorrence shown by the Apostles, of the Antinomians of their own day. They raised a prejudice against the Religion, as being far worse than no religion at all; because the doctrine they taught tends to silence the suggestions and the reproaches of natural conscience, and represents God as the encourager of vice.

5*thly*, Besides these avowed Antinomian doctrines, there are others which are liable to be so understood as to lead practically to the same consequences; though these consequences are not designed or foreseen by those who incautiously teach such doctrines. For example, there are some good, well-meaning men who represent Paul as describing, in his Epistle to the Romans, (chap. vii. 9–25,) his own actual condition. If they would read the whole chapter through, (especially verse 9,) and then go on to the eighth chapter, they would see that this is impossible; and that the Apostle is evidently describing the condition of a man under the Law, and not under the Gospel — sensible of the requirements of God's Law, but not under the influence of the Grace of the Gospel.

Now, any man who is living a life of gross vice, while he approves and admires virtue, will not be likely to be at all alarmed, or to consider moral reformation as needful, or indeed as possible, if he believes himself to be just in the *same condition with the Apostle Paul*, and all the other most eminent Christians that ever existed. And he will be likely to regard all that is said in Scripture about holiness of life, as a kind of *theory* which no one is expected to bring into practice.

Again, the doctrine that "nothing a man can do can forward his own salvation," is indeed true, in the sense that no good works of ours can establish a claim of merit in God's sight; and also in this sense, that we cannot lead a life of true christian virtue, of ourselves, and without the aid of the Holy Spirit, which "helpeth our infirmities." But if the doctrine is earnestly and continually taught *without* these explanations, the greater part of the hearers will understand it in a sense exactly opposed to Paul's exhortation, to "work out our own salvation with fear and trembling;" and they will also conclude, that if to *keep* God's commandments cannot *further* a man's salvation, to *break* them cannot *hinder* his salvation. At least, the Christian is not incited to endeavour to "grow in grace," and to "go on unto perfection." And thus the doctrine becomes, in its consequences, completely Antinomian.

ready to consent to anything for the sake of peace and unity.

(2.) And thus they are led to commit the second of those mistakes above adverted to, and to resist all correction of abuses, for fear of unsettling men's minds, disturbing the peace of the Church, and violating its Unity.

And this is especially the case when men have adopted that view of Christian Unity which represents it as consisting in having *one community on earth*, to which all Christians belong, or ought to belong, and to whose government all are bound to submit.

It is true, the same kind of feeling may influence the members of *any* Church, even one which does not claim to be "*the* universal church." For men are undoubtedly bound to be very careful not to "cause divisions" hastily, or on slight grounds. Whatever christian Church they find themselves belonging to, they are bound to give no occasion of any schism—any unfriendly separation from it, unless they are fully convinced on deliberate reflection that its doctrines or practices are at variance, in essential points, with Scripture, and that there is no reasonable hope of reform. But, on the other hand, if the rulers of any Church, force a part of its members to separate from it, by maintaining what is really thus unscriptural, (and of this the All-Wise God alone can be the infallible judge,) the guilt of the schism lies with those rulers.

The questions, however, what *is* or is not Scriptural ? and *what* points are essential ? are to be very carefully and candidly considered, under a sense of awful responsibility to God; and are questions on which different men often come to different conclusions.

And hence, while some are guilty of hastily causing divisions on wrong grounds, or on insufficient grounds, (as if each man were free to consult his own fancy or convenience in such matters,) others sometimes fall into the opposite extreme. For there are persons who will bring themselves to acquiesce in something which they perceive to be fundamentally wrong, for fear of being guilty of causing a schism.

Now this latter fault, men are much more liable to, who consider "the true Church" to be, necessarily, one community under a *single government on earth.* For all Christ's promises being made to his CHURCH, they feel that a separation from that community which they regard as the Catholic Church, would be to renounce the Gospel Covenant. And thence they are led to infer, either that Christ allows this Church to depart in important points from the written Word, or else that what plainly appear *to be* departures from it, are somehow reconcilable with it. They would, perhaps, be glad if the governors of their Church could be prevailed on to remedy such and such an abuse. But if these resolve, in compliance with the wish of the majority, to retain it, such persons consider that they have only to submit, rather than forfeit (as they imagine) *all* their Christian hopes at once. To oppose or question the decisions of the Church which they regard as the divinely-appointed Authority and Guide for all Christians in whatever pertains to religion, they consider as a rebellion against Christ. And thus they in time force themselves to believe their Church *infallible*—to assent to and uphold the grossest corruptions—and to resist all attempts at correction.

This mistake as to the nature of christian unity is one which could hardly arise in the days of the Apostles. For *they* manifestly founded many distinct Churches, agreeing indeed in Faith, but quite independent of each other, and having no common Head on Earth. And the Bishops which they appointed for the government of most (if not all) of these Churches, differed as much from the Bishops of later times, as a Sovereign prince does from a colonial governor. Each was the Head Presbyter, to whom was intrusted the chief power in an entire Church.

It was indeed allowable and desirable that delegates from these several Churches should assemble, from time to time, to hold a Council, (or, as it is called in political affairs, a *Congress*,) for the purpose of conferring together on religious questions, and concerting measures for putting down false doctrines and abuses. This did not necessarily destroy the independence of the Churches; any more than Sovereign-States surrender their independence when they send ambassadors to a Congress to deliberate concerning a treaty. But ambitious men, when they obtained a majority in any of these Councils, naturally encouraged the notion that the minority were bound to submit to their decisions, whether they would or no. This, so far, tended to combine all these Churches into one. And when the chief part of the Roman Empire became Christian, the Emperors always sought to favour this combination, in order that they might the more easily and the more completely control it.

And that this worldly policy of theirs had a principal share in the uniting of the several distinct christian communities into one, is plain from the circumstance that it was not *Jerusalem* —the earliest christian Church, and from which all others were off-sets—but *Rome*, the *political* Capital of the Empire, that came to be regarded as the seat of government, and centre of the Universal Church.

There is not, indeed, any rule laid down by divine authority, as to what is to be the greatest extent of a single Church. It cannot, therefore, be said that there is in Scripture any direct prohibition of Christians all over the world uniting themselves into one single community. But the example left us by the Apostles, in founding many distinct Churches, independent of that of Jerusalem, and of each other, shews that they did not consider a very extensive Church, as either a necessary or a desirable thing.[1] And the inconvenience is so manifest and so great, of placing under one Church-government men of different nations, far distant from each other, and differing in language and in customs, that we may be sure no such thing would ever have been thought of, except either for reasons of worldly policy, or else from a misconception of the character of Christ's kingdom. The ruler of a great empire, containing many provinces, may naturally wish that all his subjects should be members of the same Church; and the supreme rulers of any Church are likely to be tempted by ambition to extend that Church as widely as possible. Those, again, who make the mistake above alluded to, respecting the true meaning of christian-unity, will readily enter into these views. And some will be likely to fancy that the governors of a single Church comprehending all Christians, will be likely to prevent such errors as might spring up in some out of a multitude of independent Churches, and thus preserve the purity of Gospel truth. But this is to suppose that the governors of the universal Church are to be *infallible.* Else, it is plain that they may fall into error as easily as the governors of a smaller Church, and may employ their extensive power in maintaining and spreading such error. And, accordingly, all who contend for a Universal Church, in the sense of a single community under one government on earth, always lay claim,—more or less distinctly,—to infallibility as belonging to that Church.

But as no such infallibility can be proved, or does exist, the result has been that all attempts to give universal dominion to a single Church have increased the difficulty of checking and of correcting corruptions.

For example—one great abuse, and that the parent of many others, the keeping of the Scriptures and of the public Service in a dead language, was doubtless much favoured by the great extent of a single Church. The abuse was not one that originated in very early times. For it was not caused by men's having from the first a superstitious dread of any attempt to translate the Scriptures at all, and consequently leaving them in the original Hebrew and Greek. On the contrary, they were *translated* into Latin, when that was the prevailing language, on *purpose* that they might be accessible to the people. And afterwards, when Latin gradually ceased to be spoken in the Provinces, and at length, in Rome itself, the Latin Bible and Prayer-Books continued in use after they had ceased to be understood by the mass of the people. No one could point out the precise time when a new translation first became necessary; because the change of Latin into Italian, Spanish, &c., was gradual. And men had a sort of superstitious veneration for the language which they and their fathers had been accustomed to hear employed in divine Service.

And this is evidently an error which it served the purpose of an ambitious Church to keep up.[2] All over the world, as far as the dominion of that to dictate to the understanding, and to domineer over the conscience, of all the rest. For, whatever strong reasons a man may see for condemning any corruptions which that Church may have sanctioned, he will labour to stifle his convictions, and to believe any absurdity, or approve of any abuse, rather than exclude himself, as he supposes, from the true Church. So also, a mistake as to the true limits of Church-authority is one which tends to foster other mistakes. If a Church assumes the right of setting aside the precepts of Scripture, or of giving any interpretations whatever of them to suit its own views, or of "making the Word of God of none effect through their tradition," a man will be led to submit to all this against his better judgment, if he is persuaded that he is only submitting to the authority which Christ has appointed for his guidance in all that pertains to religion.

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[1] Not only were there several distinct Churches in the one province of Macedonia, and in that of Achaia, but the one Epistle to the Galatians is addressed to " the *Churches*" of Galatia.

[2] The enforcement of celibacy on the clergy, (for which there is no warrant in Scripture,) was also manifestly favourable to the ambitious views of a supreme central government, as it tended to keep the clergy unconnected with the people.

And lastly, the prevalence of this error leads to the neglect of the study of the Scriptures, and even to their being left untranslated, and inaccessible to the People. For as no one need study medical books, himself, if he is placed under the care of a skilful physician, so there seems no need for any one to study Scripture, if he has others to do it for him, whose interpretations, after all, he is bound to receive, and who are ready to tell him what he is to believe and do.

And thus *general ignorance* will soon prevail; which is the greatest encourager and supporter of every kind of error and abuse. For when the light of the Gospel which was given for the illumination of the World, is thus "put under a bushel," men are thenceforward left to grope in darkness, without any means of distinguishing truth from falsehood, or genuine Religion from the grossest superstitions.

REFORMATIONS IN RELIGION.

We have seen that corruptions of Christianity have existed, from the days of the Apostles, downwards; and that these inspired teachers warned men to be on their guard against this danger. They exhort us to "take heed to ourselves," on account of "deceitful teachers," and to "prove all things, and hold fast that which is right." Christians, then, are evidently bound to be carefully watchful against any corruption of the "simplicity of the Gospel." And whenever they shall find that any unscriptural doctrines or practices have crept in, it is their duty to exert themselves for the correction of the evil. And, accordingly, it appears that almost every one of the corruptions which have prevailed in christian Churches, was opposed, more or less, at its first introduction. Yet, on the whole, this opposition was, for many centuries, so far ineffectual, that the religion of the greater part of the christian world degenerated more and more from its original purity.

It is not our design to give an account of the various attempts made (with or without success) to resist the introduction of corruptions, or to drive them out. It will be sufficient to point out:

I. What are the principal hindrances that have stood in the way of a successful opposition to errors and abuses, and of needful reformations.[1]

II. What are the faults that reformers are chiefly liable to, and against which, consequently, men ought to be especially on their guard.

[I.] There are three mistakes frequently committed by Christians, each of which has contributed to prevent successful opposition to corruption, and correction of them.

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[1] In modern language one sometimes hears of "reforming abuses." But this is an impropriety. It is an *institution* that is *reformed*: abuses are to be *remedied*.

(1.) Some have attached too much importance to *matters not essential*, and have contended too earnestly about them.

(2.) Others—and sometimes, indeed, even the very same persons—have acquiesced in very serious corruptions, through a mistaken anxiety for what they consider *Christian Unity* and concord.

(3.) A third cause, tending to the same effects, is a mistaken *dread of innovations*. Those who are on their guard *only* against *sudden* corruptions, and overlook such as creep in silently and gradually, will be disposed to resist as innovations what are, in truth, *restorations;* and to maintain what are, in reality, *very great and mischievous* innovations.

(1.) When men are once engaged in a *contest* on any question, their eagerness is apt to increase as the debate goes on; and they often come to regard some matter that is really of very small consequence, as if it were of the greatest. Thus, their attention is often drawn off from things far more important. For example, there have been fierce controversies among Christians about the proper time for celebrating the festival of Easter. And this is one of the many cases in which the attempt to unite all Christians under the government of *one single community on earth*, has led to discord instead of concord. For, it is necessary that in any *one* Church, the times for celebrating religious festivals, should be fixed by authority; however unimportant it may be *what* shall be the time fixed. But two or more independent Churches may differ in this, and in several other non-essential points, without hostility and strife. Such questions, however, immediately become a source of strife, as soon as it is thought necessary to unite these Churches into one. And the same may be said of that most bitter dissension which arose between the Eastern and Western Churches as to the use of leavened or unleavened bread at the Lord's Supper. And at the very time when these controversies about such comparatively insignificant points were raging with the utmost fury, the unscriptural practice of applying to the Virgin and other saints as mediators, (besides many other superstitions,) was spreading widely among Christians.

So also, in later times, and even in our own day, there have been vehement debates on the question, whether a clergyman should preach in a black dress or a white one. And the attention of many persons has thus been called off from the far more important question as to the soundness of the doctrine preached. While occupied about the colour of a vestment, they have overlooked the serious corruptions of the faith introduced by such as were "teaching for doctrines the commandments of men."

And, again, the schism of the Donatists, which gave rise to one of the most furious contentions that ever existed among Christians, originated merely in a question as to the regularity of the appointment of a certain bishop.[1] These persons having taken up that notion respecting "apostolical succession" which has been noticed in a former part of this Dissertation, they would not allow that the ministers ordained by the bishop whose succession they disputed, were ordained at all; or that any whom these baptized were really Christians, &c. And while this fierce contest lasted, which was nearly two centuries, (from the fourth to the sixth,) men's attention was drawn off by it from essential points; and various corruptions were allowed to spread, unchecked and unnoticed. Moreover, one effect of such contests is, that many men are apt to become, at length, so weary of strife, as to be ready to purchase peace at any price, and to acquiesce in various abuses and errors in important points, rather than run the risk of exciting any controversy.

Now we ought certainly to prefer peace and christian concord to everything *except* the essentials of Gospel-truth and pure worship. But these must not be given up even for the sake of peace.

For, religious *agreement* is not that christian concord which it is so important to aim at, unless it be agreement in the *genuine* Religion of the Gospel. There may be an agreement in error as well as in truth.

But, vehement and long-continued disputes about matters of minor importance which are not worth so much contention, will often drive men into the opposite extreme, and make them

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[1] Cæcilian, elected Bishop of Carthage, 311.

Again, some teach that Christ's obedience to the divine law is imputed to believers in Him; so that the good works He performed are reckoned in God's sight as performed by *them.* This doctrine, though not warranted by Scripture,[1] is taught by some who are themselves striving to lead a virtuous life. But their hearers will be likely to conclude, "if Christ's *suffering* for us and in our stead, is to exempt us from suffering in *our own* persons, then, by parity of reasoning, his performing in our stead good works which are imputed to us, as if *we* had performed them, must exempt us from all need of keeping God's commandments ourselves." And though this may not be an inevitable conclusion, and explanations may be given which will avoid it, still, we may be sure that there *will* be a danger of men's drawing such an inference. And for this danger those teachers will be responsible who set forth a doctrine not clearly taught in Scripture.

And some there are who dwell exclusively on the efficacy of faith; teaching (which is quite true) that genuine christian faith will not fail to bring forth the fruit of a christian life. But if they do not at the same time teach, as our Lord and his Apostles do, the necessity of "*running*,"—"*striving*,"—"*watching*,"—being "*careful*," (1 Cor. ix. 24; Luke xiii. 24; Mark xiii. 33-37,) in their christian course, their hearers will conclude that they have only to take care of their faith, and leave christian virtue to follow of itself. And being once convinced that they have embraced the true faith, they will feel themselves in the condition of a man who has embarked on board a safe *ship*, bound to the right port, who has nothing to do but sit still, and let himself be *carried* thither. And the consequence of their thus taking no pains or care in the moral cultivation of their mind, will be, (as has been observed above,) that their religion, instead of improving their moral character, will be itself corrupted by it; and having "cast away a good conscience, they will make shipwreck of the faith." (1 Tim. i. 19.)

The above are a part, and only a part, of the religious corruptions which have been introduced or fostered by moral corruption.

V. Lastly, worldly policy has greatly helped to promote some of the worst religious errors. The same kind of men who would, most of them, have opposed Christianity, from covetous or ambitious views, when it was first preached, were disposed, afterwards, to distort the religion so as to suit those views.

Thus, any worldly men who found their way into the Ministry, were tempted to favour any kind of superstitious error that tended to bring them profit and power. The People were often disposed to fancy that the Priests could serve God in their stead, and that there were mysteries in Religion which the Priests understood, but which the Laity need not know anything of, and ought not to inquire into. And hence they were ready to follow blindly the guidance of the Priests in religious matters; just as a man trusts, in legal concerns, to his Lawyer, and in medical concerns, to his Physician; doing what they direct, and not considering it necessary himself to study Law or Medicine.

All these, and many other such erroneous notions, have been encouraged by worldly-minded Priests for the increase of their own power and wealth.

Again, ambitious and worldly-minded Rulers are generally glad to make use of Religion as an instrument for securing the submission of the People to tyrannical oppression, and for aiding their ambitious views when they seek to subdue their neighbours, under the pretext of propagating the true Faith. Such men are disposed, like the Jews of old, to "take Jesus by force to make Him a King;" that is to make his a "kingdom of this world."

Such men perceive a political advantage in having the same religion professed by all their subjects; and they endeavour to secure this object by force. They make laws for the punishment of heretics: or to exclude from civil rights every one who is not a member of their Church; or they seek to compel every one to have his children taught their Faith.

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[1] Our Lord seems to be expressly guarding against this notion in the parable of the Marriage-feast. The Wedding garment (which represents the "righteousness of Christ,"—that is the moral character which his Spirit enables us to attain to) was provided—according to the Oriental custom—by the king. But the guest who had refused to put it on was cast out without being allowed to plead—"*You* are clad in the wedding garment; your wearing it may be *imputed* to me, and may serve instead of my putting it on."

All these are so many different forms in which the spirit of PERSECUTION shows itself, in varying degrees of violence.

Now, it is of course most desirable that all men should agree in true christian faith and practice. But then, this profession of the Religion should be *sincere* and *voluntary*. It is utterly contrary to the spirit of Christ's religion to attempt to maintain or to propagate it by force. But it belongs to the "natural man" to feel jealousy and dislike of those who differ from us in opinion on important points; and, when we fail to convince them, to wish to force them to submission; or at least to keep for ourselves what is called a "political ascendancy" over them. And those who have a zeal for what they consider true religion, but who are strangers to the genuine spirit of the Gospel, persuade themselves that they are seeking God's glory and the good of mankind, in carrying out their own intolerant principles. Since Governments, they say, ought to seek the *good*,—universally,—of the subjects, and true religion is the greatest good, it must be the duty of the Civil Magistrate to insist on his subjects adhering to a true religion.

But they overlook two circumstances: 1st, that since the Magistrate must, by this rule, be himself the judge *what* religion is true, it would follow that the Jewish Rulers had a right to forbid the Apostles to preach the Gospel; and that the Apostles were bound to obey; and, 2dly, that though the *sincere* acceptance of true religion be the greatest good, an outward profession, in obedience to the laws, of what a man does not really believe, is no good at all, but a great evil.

Yet all this is overlooked by those who "have a zeal towards God, but not according to knowledge" of the true Gospel.

In addition, however, to mistaken religious zeal, there can be no doubt that men's minds are often biassed towards this particular corruption of Christianity, by worldly policy. The love of power and worldly pre-eminence helps to give their turn to their religious zeal. And thus they so far mistake the real character of Christianity, as to imagine it allowable, and even a sacred duty, to put down religious errors by force, or to secure a monopoly of civil rights in behalf of the members of their own Church.

The above, then, are the chief sources from which corruptions of Christianity have sprung. And they correspond to those from which, as we have seen, originated the chief part of the early opposition to the religion, viz.: mistaken adherence to the Mosaic Law; superstition; misapplied philosophy; moral depravity; and worldly policy.

As for the *means* by which various religious errors have been kept up and spread, one of the principal is that employment of *coercion* which has been just noticed. As a general rule, a resort to restrictions, and to force of every kind, must be, on the whole, more favourable to error than to truth, in all subjects: because it tends to take away the great *advantage* which truth has over error. Truth being in itself stronger than falsehood, may be expected to gain a superiority when there is free discussion. But Laws and Penalties may be on the wrong side as well as on the right. Those, therefore, who resort to these, may, not unfairly, be presumed to have themselves, some distrust of the goodness of their cause, since they remove the trial from a Court (that of Reason) in which truth has an advantage over falsehood, and appeal to brute-force, in which truth has no such advantage. A fair and *free trial* is what, generally speaking, the intelligent advocates of truth, in all subjects, will be likely to call for, and the advocates of error, to deprecate. Moreover, in regard to religious questions, the resort to coercion proves a person to have totally mistaken the character of Christianity as to *one* most important point; so that there is a probability that he will have mistaken other points also.

That erroneous view, again, of christian *Unity*, which has been already noticed, has tended very much to keep up and to extend other errors. For if a man is once convinced that all Christians are bound to belong to some one Community on earth, he will dread nothing so much as separation from that Church, whatever it may be, which he considers as having the best claim to *be* that one community.

And thus, a *majority* will be enabled completely

Church extended, the Priests had a language of their own, not understood by the common people, and in which alone the Sacred Books could be studied. And thus the People could know little or nothing of their Religion, except just what these Priests chose to tell them.

Now it is true, indeed, that the same error might find its way into each of several independent Churches, however small. It is conceivable, for example, that independent Churches in various parts of the world might have retained, some, an ancient Gothic translation of the Bible, some, an Anglo-Saxon, &c., long after those languages had ceased to be spoken. But then it is far less likely that *every one* of forty or fifty independent Churches should persist in this error, than that *one* should do so. And if *some* of those Churches, or even any one of them, had made new translations of the Bible to meet the wants of the People, the others would have been shamed into following their example in a thing so evidently reasonable.

And this is proved by what has actually taken place. It is well known that at the time of Luther's Reformation, and long before, the translating of the Scriptures into modern languages was most earnestly opposed by those who adhered to the Church of Rome. The Scriptures, which were originally addressed to Christians of all classes, including slaves, were represented as unfit for the perusal of the common people. But since then, the Roman Catholics have in some measure followed the example of those Churches which they denounce as heretical.[1] They have among them now, (though not in perfectly free circulation,) translations of Scripture into English, French, Italian, and other languages. And some of them have also Prayer-books, with the Latin and their own language printed in parallel columns, so as to enable them to understand the Service that is going on.[2] There can be little doubt, therefore, that this would have been done long before, if there had been all along numerous independent Churches, such as the Apostles established.

It is true, indeed, that before the time of that Reformation, and indeed, in a less degree, for a good while after it, the prevailing ignorance was such, that few besides the Clergy could read at all. But then it should be remembered, first, that to have the Church-Service—including the reading of the Scriptures—in a language understood by the People, is a most important benefit even to those who cannot themselves read; and, secondly, that this gross ignorance would not have *existed* if the Clergy had all along done their duty in presenting to the People the Scriptures in their own language, and encouraging them to learn to read, for the very purpose of studying those Scriptures as they ought.

It is plain, therefore, that the abuse we have been speaking of was left much the longer unremedied in consequence of the dominion of *one* Church of vast extent.

And the same may be said of many other abuses. A reform that is evidently needed, is more likely to be resisted by *one* community, than by *every one* of many independent communities. Any one out of several distinct Churches, when it corrects something that is manifestly wrong, sets an example which others are not unlikely to follow. And this advantage is wanting, when all or nearly all Christians are put under one single government.

The causes above mentioned have proved, in very many instances, great hindrances to needful reforms. Nevertheless, many attempts were made, in the earlier Ages of the Church, to introduce errors and abuses, which were vigorously and often successfully resisted. We have on record many varieties of false doctrine and corrupt worship, (most of them now nearly forgotten,) which were generally condemned and expelled as heretical.[1]

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[1] This great and important *change* completely disproves what is maintained by the advocates, and by the bitterest enemies, of the Church of Rome—the *unchangeable* character of that Church. But there is nothing so grossly and notoriously false as not to gain credence, if maintained by both of two opposite parties.

[2] As for the celebration of Divine Service in Latin, it has ever been made a matter of boast by the Roman Catholics, that in a foreign Country, a priest going thither ignorant of its language, can at once perform Service, as at home; and that a traveller equally ignorant of the country, can attend the Service of his Church, which is the same everywhere; while a member of any other communion would be at a loss. This is as if a blind man should make it a matter of boast that he is not incommoded by the short days of winter, and has no occasion for candles. That day and night are alike to him, would indeed be an advantage, if he could see in *both*; but not, when the case is that he can see in *neither*.

Unfortunately, indeed, it often happened that the mode in which many of the ancient heresies were opposed, was such as to have the effect of giving rise to fresh heresies. But it was with good reason that the majority of the early Christians—and, indeed, of Christians in all ages—always opposed (though not always wise in their mode of proceeding) every *innovation* in doctrine. They justly considered, that anything *new* (in essential points) introduced into Christianity must be wrong.

But then, they often committed the fault of being on their guard *only* against *sudden* corruptions;—against any innovation brought in *openly* and all at once. They overlooked (as men are apt to do in all subjects) the principle so well laid down by Lord Bacon, that "*Time* is the greatest innovator;" that it "introduces changes so silently and gently as to escape notice;" and that "since things alter for the worse *spontaneously*, hence, if they be not altered for the better designedly, there will be no end of the evil." To resolve that *no* changes shall take place, is to talk idly. One might as well forbid the winds to vary, or the tides to flow. But to resolve that no changes shall take place *except* such as are *undesigned* and accidental, is to determine that though a clock may gain or lose indefinitely, we will take care that it shall never be *regulated*.

What is called "the change of the *style*," is a striking instance of a seeming *innovation*, which was really a *restoration*, being a return to the right course, by the sudden correction of a great error that had resulted from the accumulation of imperceptibly small ones.

In religious matters, a remarkable instance of a *gradual* corruption, and a *sudden* reform, is the point already noticed,—the keeping of the Scriptures in a language unknown to the People. This was a most enormous *innovation;* since the Sacred Writers manifestly addressed themselves to Christians of all ranks. But it was overlooked, because it was no *sudden* innovation. The Latin language went out of use *gradually*. No one can fix the precise day or year on which a fresh translation was first needed. But when men did perceive the need, and translated the Bible into modern languages, this was a great and palpable *novelty*. And, as such, it was vehemently opposed; though, in reality, it was, in spirit, a *restoration* of the original state of things; the placing of the Scriptures before the People in a language which they understood.

So, also, there can be no doubt, that the change of christian Ministers into *Sacerdotal Priests*, making offerings on an altar, and also the custom of invoking saints, and most of the other corruptions already noticed, crept in gradually and insensibly.

The fond veneration for the memory of any holy martyr led men to visit his tomb, and to preserve carefully his garments, or other relics, and also images or pictures of him. They naturally prayed to God, with these images before them, for grace to follow the good example of such a holy man. And thence they were gradually led to beg for his intercession, and, in fact, to worship him.

Then, when this had become a long-established corruption, and when men were called on at once to renounce it, and to pray to none but the all-present God, many were startled at the *innovation*, and resolved to keep to "the *old* religion," and to worship as their ancestors had done for centuries, rejecting as heretical all new doctrines. For, to *them*, the observance of the first and second commandments *was* a novelty; though, in reality, it was only a *return* to the primitive worship.

And so it was, no doubt, with the greater part of the corruptions that crept into Christianity.

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[1] It should be observed that a "Heretic" properly signifies a person who maintains some false doctrine condemned by the *Church of which he is a member*. No *Church*, therefore, can be, in strictness of speech, *heretical*, though it may be erroneous. Accordingly, the Church of England, for example, pronounces the Church of Rome to have "erred;" but does not apply the term "heresy" to its errors, because it acknowledges the Church of Rome to be a distinct, independent Church. The Romanists, on the other hand, pronounce the Church of England "heretical," because they reckon all Christians as members—even though disobedient and rebellious members—of their own Church. Those of them at least who do *not*, (for there is a good deal of uncertainty on this point,) cannot maintain that their own Church *is* Universal [Catholic] in the ordinary sense of the word, namely, as *actually* comprehending *all* Christians. They should rather call it "the Church which *seeks* to be Universal."

Men were not sufficiently on their guard against them, because they came in by little and little. And then, when correction was attempted, many resisted it, and would not allow that these *were* corruptions, because no one could point out the precise time when they arose.

But if we look to SCRIPTURE, and compare with this the doctrine and practices of some christian Churches, it will be plainly seen that their religion *has* been corrupted; though we may not be able to say exactly *when*, or by what means.

And this is the only safe course of proceeding. For when a book, for instance, is often reprinted, the only way to insure accuracy is to collate carefully each edition with the original copy. Sometimes this is neglected, and the second edition is printed from the first, and the third from the second; and so on, down to perhaps twenty or thirty editions. And the result has generally been, that though each edition has but a very few fresh misprints, and differs but very little from the preceding, yet the twentieth or thirtieth edition will be found, when compared with the original, to be excessively incorrect, through the accumulation of a multitude of small errors.

In like manner, if we would keep our Religion pure, both from new and from old corruptions, we must go straight to the very fountain-head itself, and observe what is or is not agreeable to the inspired Word.

[II.] From the causes, then, which we have been speaking of, the correction of various abuses was so much impeded and so long delayed, that thorough *Reformation* (or as it might have been more wisely called—a *Restoration*) became necessary.

By the "reformation" of a Church is generally understood a *fundamental change* in doctrine and worship, as distinguished from slight alterations. And we use the word reformation in a corresponding sense, in reference to any other Institution also. It is like the pulling down and *rebuilding* of a great part of a house, as distinguished from the many small *repairs* which are made every year by a prudent man, and the occasional small improvements he may see need for. Those repairs and improvements he makes on purpose that he may be saved from the far greater cost and inconvenience of rebuilding, which is an evil in itself, though a necessary evil when timely repairs have been neglected.

So also, every reformation is an evil, on account of the general disturbance and agitating alarm it tends to produce. But this is a less evil than the utter corruption of Christianity. And there is no other alternative when errors and abuses have been long suffered to accumulate, and all timely remedies have been obstinately rejected.

But many persons are led by their dread of the evils and dangers of a reformation, to oppose it as long as possible, and to endeavour to delay it; not considering that the longer it is deferred, the more violent and dangerous it is likely to be.

The principal dangers to which reformers are liable, may be classed under these two heads:—

(1.) They are apt to feel too secure against falling into the faults of the system they are reforming. They often *retain* several of their former wrong notions; and accordingly commit some of the same errors, in substance, though in some new shape—as those they undertook to remedy.

(2.) And, secondly, they are apt not to be sufficiently on their guard against *reactions*. In their abhorrence of what is wrong, they have often rejected what is right along with it, and have often rushed from one extreme to the other; not considering that there may be two errors quite opposite to each other, and that men in their eagerness to avoid one fault, will often be blinded to the danger of committing a contrary fault, that is, perhaps, even worse than the first.

(I.) When men feel a very strong abhorrence of any fault in the particular form in which they have been used to see it, they are apt to feel too much self-confidence in reference to that fault; and not to be on their guard against falling into (substantially) the same fault in some other shape.

For example—the detestation felt by the early Christians for the pagan worship of the images of Jupiter and Juno, and other gods and goddesses, made them feel secure against any danger of idolatry, in a christian Church. And this absence of self-distrust contributed to their falling into similar superstitions under different names, by paying adoration to images of Beings whom they do not call *gods and goddesses*, but male and female *Saints*.

So also, in the present case, reformers often retained some of the erroneous principles which had led to the abuses they were correcting; and thus they frequently themselves committed like errors, though in a different shape.

For example, they were fully convinced that the claims of the Church of Rome to *infallibility* are unfounded. But many still clung to the notion that infallibility must be lodged *somewhere* on Earth. They still thought a divine *Revelation* necessarily implied an unerring guide for the right *interpretation of that Revelation.*

Some of them, accordingly, fancied that there must be somewhere, though not at Rome, an infallible Universal Church; though they sought in vain to find any person or Body of men having acknowledged power of any kind, over all Christians, and entitled to represent and to dictate to the whole christian World.

And there are, even now, not a few persons, members of reformed Churches, who suffer themselves to be mystified by the vague and obscure language of artful leaders, and to be deluded into a belief in the infallibility of a certain Universal Church, consisting of all the "orthodox," that is, all those who agree in opinion with those leaders. And thus they fancy themselves bound to receive as gospel truth whatever they are told by those leaders, whom they regard as most *profound* theologians. For as muddy water is often supposed to be *deep*, from one's not being able to see to the bottom of it, while that which is exceedingly clear is thought shallower than it is, so, weak men are apt to admire as very profound, in Theology or in Philosophy, what they cannot clearly understand, and to despise as shallow, whatever is made very plainly intelligible.

Others, again, of those who cling to the notion of an infallible interpreter of Scripture, have concluded that every sincere Christian, or that they themselves, or that certain persons whom they look up to as pre-eminently holy, do possess this unerring guide, in the inspiration of the Holy Spirit. Whatever is really dictated by that Spirit, they justly concluded must be infallibly right. And they found in Scripture promises of the aid of that Spirit. They inferred, therefore, that whatever occurred to their minds, after having prayed for this spiritual aid, must be the true interpretation of Scripture; which, consequently, all men are bound to acknowledge and submit to.

It is remarkable that most of the persons who put forth such claims, do not pretend to exemption from *Sin*, though they hold themselves to be exempt from the possibility *of doctrinal error*. To suggest a doubt as to the truth of any *doctrine* they maintain, they regard as questioning the truth of God Himself. But for any man to account himself *impeccable*, they consider as an impious presumption. And yet the office of the Holy Spirit is to lead us, not only "into all *truth*," but also into "all *righteousness;*" for "the fruit of the Spirit is in all goodness, and righteousness, *and* truth." And though both are highly important, most persons would allow that this latter is the more so. If a man were offered the choice, —supposing he could not have both,—of being completely secured, either from all *mistakes* in doctrinal points, or from all *sin*, he would hardly hesitate to acknowledge that the latter would be the more valuable gift. Yet the very same persons who make no claim to *unerring rectitude of conduct*, and exemption from *sin*, will hold themselves to have attained unerring rectitude of *judgment*, and exemption from *error;* and will regard any doubt on *that* point as a distrust of God's promises. And yet they are no more promised infallibility than impeccability.

Some, however, there are who seem to think that both in doctrinal questions and in moral questions also, their *judgment* is infallibly right; and that though, in practice, they are liable to go wrong, this can only be when they offend *against* the dictates of their own conscience. This is to claim a great superiority over the Apostle Paul, and to reverse his procedure. For *he* says "I judge not mine own self; for I know nothing against myself;"[1] (that is, I am not conscious of any wrong;) "yet am I not hereby justified: but He that judgeth me is the Lord." *He* therefore did *not* set up his own conscience as an infallible standard of right and wrong.

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[1] *Οὐδὲν γὰρ ἐμαυτῷ σύνοιδα.* 1 Cor. iv. 4.

A circumstance, however, which is still more remarkable, is this; that many of those who thus in reality lay claim to "*inspiration*" and "*infallibility*," yet carefully keep clear of those *words*. They do not *call* themselves inspired or infallible. And yet it is plain that a man who feels quite certain that his interpretations of Scripture are suggested by the very Spirit which dictated that Scripture, is, so far, claiming just as real an inspiration as the Sacred Writers themselves possessed. If he feels quite certain that he is *unerringly following* an *infallible guide*, he must in reality regard himself as infallible.

In this, as in many other cases, men are misled by *names*. They mistake for two different doctrines what are in reality only two different expressions of the very same.

When, however, a large portion of the christian World which had been under the dominion of a single Church, had thrown off that yoke, the danger of falling into the mistake of looking for an infallible guide on earth was much diminished. For those inclined to such a notion would naturally, as long as they were under *one* Church, look to that Church as the seat of the infallibility. But when they were separated into several distinct communities, the error tended—if one may so speak—to cure itself.

For then, several *conflicting* claims to infallibility were of course put forth, by persons teaching *different* doctrines, yet who each professed (and doubtless often with truth) to have earnestly prayed for inspiration; and as it was plain that *all* these claims could not be well-founded, this naturally put men on inquiring whether *any* of them were so. And then, all sober-minded men perceived that the only *proof* of inspiration, and that which must necessarily accompany it—the display of *miraculous* signs—was wanting in *all* the claimants; and consequently, that no infallible guide on Earth has been provided.

But the error, though greatly checked, is still to be found among weak-minded enthusiasts, who cannot, or will not think accurately.

It is kept up in them in great measure, by their confounding together the infallibility of the guide in *itself*, and *our* infallibility in following that guide. For instance, if, on the one hand, the mariner steers by a *chart*, then, even though he conform to it quite exactly, yet if this chart itself be at all incorrect, he may be misled by it. If, on the other hand, he steers by a star, he is sure that his *guide* cannot be wrong; but yet he may be misled if he mistakes one star for another. If, however, he is convinced that this is totally impossible, and that he is *infallibly following* an infallible guide, it is plain he reckons himself infallible.

And even so, though the Scriptures and the Spirit of God cannot themselves err, no one has a right to pronounce confidently that he is exactly conforming to them, unless he is favoured with some sensible miraculous signs from Heaven to assure him of this. Without such a sign, "if we say that we have no sin"—or that we have no error—"we deceive ourselves." For even if, in some point, our judgment or our conduct *be* in point of fact perfectly right, still, as we cannot with perfect certainty *know* this, during our state of trial on Earth, we have no right confidently to claim it.

Another wrong principle which has been retained by many reformers, is that of *persecution*. By the *principle* of persecution, we mean the notion that it is allowable and right to use secular coercion in religious matters, or to maintain what is called the political "ascendancy" of those who profess the true Faith; so that they should monopolize civil rights and privileges.

The reason why we speak not of *persecution* itself, but of the persecuting *principle*, is, that where this principle is the most thoroughly carried out, there will be no *actual* persecution. In any country where all who dissented from the Established Faith have been either killed, or banished, or compelled to conform, there is no longer any one to be persecuted. No tree is destroyed by the scorching drought of the African Deserts, or by the intense frost of the Polar regions, because no tree can grow there. And in the most intolerant Countries on the Continent, no heretics are burnt, because there persecution has finished its work.

And accordingly all persons agree in professing (and generally, no doubt, with sincerity) to be averse to persecution. Nebuchadnezzar, who condemned Shadrach, Meshech, and Abednego to the flames, and those Roman Emperors under whom so many christian Martyrs suffered, wished them rather to save their lives by worshipping the heathen gods. And it is the same with all, down to this day, who hold the persecuting principle.

Now, that principle was not renounced by most of the earliest Reformers. They complained, indeed, of the persecutions they *themselves* were exposed to. But this was not from any doubt that heretics ought to be punished, but because they denied that *they* were heretics. Persecution they considered as consisting in penalties inflicted on those who profess the *true* Faith, which, of course, they held theirs to be. To put to death such as are really heretics, was, in their view, no persecution.

By degrees it came to be perceived, that this principle leads to a war of extermination among all persons of different persuasions. And men began to adopt notions more humane, but not at all consistent either with the Gospel, or in themselves. They considered it as too severe to *burn* heretics, or even to put them to a less cruel *death*. But they thought it right to punish them by fine and imprisonment, either for refusing to profess what they did not believe, or for persisting in teaching doctrines which they felt themselves bound to propagate. (See Acts v. 28.)

And others, again, went further, and were for inflicting no punishment on those who do not hold the true Faith, but only excluding them from the rights of citizens; so as to secure to the "true believers" a monopoly of civil power.

But all these different classes of persons agreed in the erroneous principle which goes to make Christ's, a "kingdom of this world."

Many persons imagine that there is a necessary connection between these views and a belief in the infallibility of a certain Church, and of the impossibility of salvation out of it; as if no one could think it right to persecute for religious error unless he thought himself exempt from all possibility of error; and again, as if every one who does think this, must be a persecutor.

But this is quite a mistake. For, on the one hand, a man may be confident that his is the only saving Faith, and that his Church is infallible—which was *actually* the case with the Churches under the immediate care of the inspired Apostles—and yet may be convinced, like those very Apostles, that coercion in religious matters is utterly unchristian.

And, on the other hand, a civil Ruler may so far misconceive the true character of the Gospel as to think it right to compel all his subjects to profess what appears to him to be the best religion; yet without thinking his Church or himself infallible in religious matters, any more than he is infallible in *secular* matters. Now in secular matters no Kings or Senates pretend to infallibility. They make such laws as they deem most expedient, and alter them from time to time as they see cause. But as long as those laws are unrepealed, they consider themselves (and very rightly) authorised to enforce them by penalties. If, then, they regard Religion as coming *under the province of the civil Magistrate*, they will of course apply the same rule to that also. They will feel themselves bound to take care, not only of the persons and property, but also of the souls of their subjects. They will prescribe what, in their judgment, shall appear to be the best regulations for traffic, and for keeping the peace, &c., and also the best for Religion.

And perceiving the convenience of a uniformity of Worship for all their subjects, they will be likely to regard all who do not conform to that which they have established, as enemies of the State; and thence to expel or to degrade them as politically dangerous. And thus, without making any claim to religious infallibility, any more than to general legislative infallibility, they will change Christ's kingdom of Heaven into an earthly kingdom.

It is, indeed, true that any persons whose notions in morals or in politics are such as to make it impossible that they can be peaceable and loyal citizens, may allowably be excluded, not only from civil rights, but from the right of residing at all in the Country. And if there be absolutely no other way of fixing on such persons, but by their professed religion, it is necessary (as long as such continues to be the case) to submit to the very great evil of making their religion a test to exclude them.[1]

If, for example, any one is fully convinced—in opposition to all reason and to all experience—that no Jews can possibly be good subjects, he ought to urge (not that the most unprincipled of them should be bribed by the hope of civil privileges to profess Christianity, but) that none of the Jewish Race should be allowed to reside in the Country.

But to make the profession of a certain Faith a necessary qualification for civil privileges, on the ground that it is the *true* Faith, and that the Magistrate is bound to uphold the true Faith, and to make the Church and the State *one community*, &c.; all this is evidently making Christ's a Kingdom of this World.

Gradually, juster views of the true character of that Kingdom prevailed more and more both among Protestants and Roman Catholics. But even now, these views are far from being universally acknowledged.

To the instances that have been noticed, others might have been added, of the same class; that is, instances of reformers retaining or reviving some of their former wrong notions, or practices, in some different shape. But what has been now said is sufficient to shew how careful men ought to be not to flatter themselves that when once they have reformed a corrupt system, or renounced a corrupt Church, they are thenceforward safe from like corruptions. If the corruptions are such as have their origin in the nature of Man, and (as is generally the case) are rather the *cause* of the faulty system, than the *effect* of it, it is against the infirmities of human nature that we should the most watchfully guard.

(II.) The other class of errors formerly mentioned as likely to be committed by reformers, are those which arise from what we called the tendency to *reaction;* to "mistake reverse of wrong for right," and thus to rush from one fault into another fault of the contrary extreme.

For example, many christian doctrines having been corrupted by "philosophy and vain deceit," and mixed up with presumptuous and absurd speculations, the result has been, that some have been led to reject the doctrines themselves as taught in Scripture.

Thus, the doctrines of our Lord's divine Nature, and of his Atonement, have been by some reckoned among the early corruptions of Christianity. This was doubtless caused, in a great measure, by men's being disgusted with the rash metaphysical explanations of those doctrines which have been given by some who were accounted profound theologians; and which others, equally rash, have confounded with the doctrines themselves. And some have even gone so far as to represent the Apostles as having mistaken their Master's meaning as to these points, or mixed up their own fancies with his revelations; so as to have preached a different Gospel from what He designed, and to have led their followers into idolatry. For, the arrogant pretensions to a perpetual inspiration *in the Church*, and its consequent infallibility, having been found utterly groundless, a reaction ensued, which led some to deny the inspiration of Paul himself, which he established by the miraculous "signs of an Apostle."[2]

Some, again, have fallen into an extravagance which prevails a good deal at the present day; that of interpreting any part of Scripture they please, *allegorically*, as being what they call a "Myth," though stated by the Sacred Writers as a simple fact. According to these persons, Scripture is true indeed, but true only in the sense which they chuse to put on it, and utterly untrue in the sense in which it was understood for many centuries, and in which the Writers *knew* it was understood. To call this a *Revelation* is a manifest contradiction. But what such persons really mean, or really believe, no one can decide. For, by their own shewing, they have so low a moral principle as to think it allowable for a man to teach what he is conscious is false in the sense in which he *knows* it will be understood; this being the conduct they attribute to Writers whom they regard as God's messengers commissioned to instruct mankind.[1]

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[1] See PALEY'S *Moral Philosophy.*

[2] The Religion of Mahomet may be reckoned as one of the corruptions of Christianity, and as owing, in some degree, its origin, or at least some part of its wide diffusion, to a reaction against opposite corruptions. For the Mahometans, though they account Mahomet a greater prophet than Jesus Christ, yet confess Jesus to be the Christ,—to have been really sent from God,—to have been superior to all who came before Him,—and to have established his claim by miracles. And the chief part of the fables which they have mixed up with the Gospel-history, they borrowed from some of the earliest heretics. This religion, in short, is evidently a corrupted offshoot of Christianity.

At the time when Mahomet arose, a great part of the Christian world had fallen into saint-worship, and the adoration of pictures and images; and had also corrupted the doctrine of the Trinity into something very nearly approaching to Tritheism. Against these errors he vehemently protested, dwelling strongly on the Divine Unity, and on the duty of renouncing every kind of idolatry. But the principle of persecution—already admitted by most Christians,—he retained and vigorously carried out. And along with the errors he rejected, he discarded also great part of the fundamentals of Christianity, besides introducing much false doctrine of his own.

Others, again, justly considering Holy Scripture as the only sure foundation of christian doctrine, and perceiving that to set up the authority of Church-tradition as an infallible interpreter of Scripture, might make Scripture say anything whatever, so as to render "the Word of God of none effect,"—and perceiving also that to shut out the People from the reading of Scripture is a monstrous abuse,—were led into an opposite extreme. They were for discarding all catechisms, and other human statements of christian doctrine, and depriving every Church of the office of teaching. They were for simply putting the Bible into each person's hands, and leaving him to make out, by his own unassisted study of it, whatever religion he could for himself. They forgot that, of all the books of the New Testament, there is not one that was written for the purpose of making known the christian Religion to those who were *quite strangers* to it. On the contrary, all those books were evidently written for the use of such as were already Christians, who had been carefully instructed [catechised] (See Luke i. 4.), and examined in the christian Faith.

It is the office of a Church to *teach*, and of Scripture to *prove*. We should study the Sacred Books carefully, as alone possessing divine authority in matters of faith. But we should study them with the best helps we can obtain; and with care not to mistake the character of them, and the purposes for which they were written. In short, we should imitate the Bereans of old, who did not refuse to hear the teachers that came among them, but "searched the Scriptures daily, to see whether those things were so" which were taught them, (Acts xvii. 11.)

Human teaching bears the same relation to Scripture, that what is called "paper currency" does to the precious metals. Bank-notes and Bills of Exchange, though of no *intrinsic* value, are a very convenient circulating medium so long as they really *represent* gold or silver, and are payable in coin on the demand of the holder. But if these notes are made a legal tender, and are required to be received in payment, by the decree of the very government which issues them, and on its bare word, without being convertible into gold and silver, the result is, that those metals soon disappear, and men are cheated of their goods in exchange for worthless bits of paper.

Even so, as long as human teaching is really a *representative* of Scripture, and Scripture proof is always ready to be given, of whatever is taught, then, and then only, we are secured against the danger of having God's Word superseded by "doctrines which are commandments of men."

Then, again, some men's horror of the doctrine, that good works can claim merit in God's sight, and that pilgrimages to certain supposed holy spots, and various kinds of self-torture, can atone for sins, led them into the Antinomian error of the ancient Gnostics. They taught the doctrine of justification by faith, in such a sense as to contradict the Apostle James, (ii. 17–26,) or at least to leave their hearers utterly careless about christian holiness of life.

Other instances might be given of corruptions of christian doctrine, arising in great measure out of a reaction against opposite corruptions.

With respect to religious *ordinances* again, the burdensome and often superstitious rites with which christian worship has been in some Churches overlaid, have created such a reaction, that some have even gone so far as to reject the Sacraments distinctly appointed by Christ Himself, and administered according to his direction by his Apostles, (1 Cor. xi. 23–26.) And the perversion of the office of christian Ministers by those who have made them Sacerdotal Priests, has driven some into a rejection of a regular christian Ministry altogether.

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[1] See Dr WEST's "Discourse on Reserve," and Essay i. on the "Kingdom of Christ."

Others, again, not going quite so far, have yet thought themselves bound to reject all institutions and ordinances that are not expressly enjoined in Scripture. There had been a manifest abuse of Church-authority in introducing *ordinances* and *customs* that are *contrary* to Scripture; and again, in teaching *doctrines* that are not *contained* in Scripture. And this produced a reaction, which led men to confound these two things together, and to deny the power which manifestly belongs to a Church, of making bye-laws respecting matters intrinsically indifferent, and in which Scripture gives no commands.

And some reformers seem to have been led by their deep detestation of the corruptions they have protested against, to endeavour to be as *unlike* as possible to the Church from which they have revolted, even in matters indifferent: altering for the sake of change. They ought to have considered that the *presumption* is always against a change; that is, since change is not a good in itself, none should be introduced unless it can be shown to be needful, and to be a change for the better.[1]

It is true, we may very rightly alter or reject things, good or harmless in themselves, when they are found to be very liable to *abuse*, or when they cause unnecessary offence. Thus "Hezekiah brake in pieces the brazen serpent which Moses had made," when he found that the Israelites burned incense before it. And the Apostle Paul, though he decides that there was no harm in eating meats offered to idols, yet forbids the Corinthians to do so, when their eating it would be misapprehended and cause offence. So, also, a statue or picture of Christ, or of any eminent Christian, is not an evil in itself. But when it is found that the vulgar pay adoration to images or pictures, or that others apprehend them to be doing so, then such images should be removed from places of worship, as being a snare to weak brethren.

This, however, is no exception to the above rule, but an application of it. For in such a case, there *is* a good *reason* for the change.

Lastly, the usurpation and extravagant claims of a Church have driven some persons to set at nought Church-government altogether, and to overlook entirely the sanction which our Lord Himself gave to christian communities, and the powers which He conferred on them. The erroneous and over-strained notions of Church-unity which have been above noticed as having contributed to maintain corruptions and to hinder reforms, afterwards led to such a violent reaction, that many thought nothing of the guilt of Schism, and seemed even to forget that there was such a thing. And this, in turn, has sometimes produced a contrary reaction. The disgust and alarm caused by those who revolt against all rules, and discard the very notion of a christian community, have driven others to submit to the grossest abuses of Church-authority, for the sake of good order and peace. It is just so, that, in political affairs, also, there is a constant reaction between tyranny and anarchy; each in turn tending to produce the other.

Many more instances might be adduced; but what have been noticed are sufficient as specimens, to shew how watchful reformers ought to be against the tendency to reaction—against suffering incautious zeal to hurry them from one extreme into another.

We shall now proceed to treat somewhat more fully of the questions relating to Church-unity.

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[1] See Preface to the Book of Common Prayer.

CHURCH ALLEGIANCE AND SEPARATIONS.

It has been pointed out that the correction of abuses and corruptions in Religion has been, in most instances, resisted and long delayed; partly from an undue attention having been directed to points of *minor importance*, which has drawn off men's thoughts from very serious errors; partly from mistaken notions respecting *Church-unity;* and partly from a mistaken dread of *innovation*, causing men to overlook what are in reality the greatest innovations.

From these and other causes, various corruptions have often been allowed to go on unchecked by timely remedies, and to increase, till a thorough reformation was necessary; and indeed much longer. And the longer a reformation is deferred, the more difficult, and the more dangerous and violent, it is likely to be.

In particular, a reformation very long delayed is the more liable to those two classes of evils mentioned above; [I.] the danger of retaining some of the former wrong principles, so as to revive, under a new form, the faults which had been corrected; and [II.] the danger of *reactions*, leading men from one extreme into another.

[I.] For, the longer any corruption has been allowed to prevail, the more it will have wrought itself into men's character, so as to have affected their mind throughout, and become, as it were, a part of themselves. And then, the same fault, substantially, will be the more likely to reappear in a different shape.

Thus, for instance, when the principle of persecution, above adverted to, had been so very long acted on, that men all over the world had been familiarised to the putting down of heresies by sword and fire, and the enforcement of the profession of the true Faith by the Civil Magistrate, as an indispensable religious duty, the consequence was, that reformers, even when exposed to persecution themselves, still clung to the faulty principle. They considered persecution, (as was before observed,) as consisting in punishing those who maintained the *truth*. And it was long before they came to perceive,—what Scripture so very plainly points out,—the inconsistency with Christ's Religion of all use of coercion in his cause. And some remain blind to this, even down to the present day.

And, again, when *ignorance* of the true character of Christianity, resulting from the non-translation of the Scriptures, had been very widely spread and long continued, and then, persons who had very little mental cultivation, and who had been trained from childhood in most erroneous religious notions, suddenly came to the perusal of the Scriptures, (often without any assistance,) it naturally happened that many of them fell into gross mistakes as to the meaning of what they read. In particular, they often mixed up together confusedly the Law and the Gospel; and often read *detached passages*, taken at random, without any reference to times, places, persons, and occasions. And thus among many, ignorance of the true character of Christianity continued, in a great degree, to prevail, though in a new shape.

This has been often brought forward by the opponents of the Reformation, as a proof of the danger of putting the Scriptures into the hands of the People. But if christian Ministers had all along done their duty in training the People to an intelligent and profitable study of Scripture, this evil would have been, for the most part prevented. Instead of this, they had kept them ignorant and uneducated, generation after generation. And mankind had been so long blindfolded that they could not see clearly when the bandage was removed.

[II.] And again, the longer and the more obstinately any needful reform has been resisted, the more fierce in general will be the spirit in which it is at length effected. Abuses which have been maintained long after they have been exposed and complained of, men are apt to correct with an angry and indiscriminate violence, which often leads them to rush into extremes, and to reject what is true and right, along with what is erroneous and faulty. Thus, one may sometimes see long-continued tyranny succeeded by revolutionary anarchy; and a long reign of ignorant superstition, even by avowed Atheism.

Many, also, of the evils which are apt to accompany any great religious reformation, have been increased by the *too great extent* of a single Church.

The Apostles appear to have founded a distinct Church in each considerable city; as at Philippi, Thessalonica, and several other cities in Macedonia, and elsewhere. Now, if some corruption had found its way into these Churches, and one of them—suppose Philippi—had reformed itself, although it is likely that some degree of jealousy and disapprobation would have at first arisen in the other Churches which were as yet unreformed, and though the Philippians might have been censured as having taken a rash step, at least they could not have been denounced as schismatical *revolters*. No one could have complained that they had *separated* from a Church of which they were subjects. They could not have been viewed in the light of *rebellious children*, throwing off the yoke of an authority they had been subject to.

But when a multitude of Churches were united into one vast Community, comprehending many great Nations spread over extensive Regions, then any reformation not embracing the *whole* of this great Church, necessarily implied *revolt* and separation.

Any branch of that Church which resolved to correct abuses that were obstinately retained by the supreme central Authority, was compelled to throw off submission to that Authority, and to assert its independence. And then, those who adhered to the Church which claimed to be the Universal Church, naturally regarded the others as not only erroneous, but Heretics and Schismatics.

And such they undoubtedly *would* have been had they separated on insufficient grounds. They had done that which *would* have been sinful, if it had not been justified by the corruptions in essential points of Faith and Worship, which the supreme central Authority had obstinately refused to correct. This refusal transferred the sin of causing the division, from the revolters, to those who made the revolt necessary.

But of course a separation thus effected gave rise to much more hostile feelings on both sides than would have been likely to exist between Churches that had been *originally* distinct, and had always continued so; neither claiming any control over the other. Such Churches might, indeed, have been to a certain degree alienated from each other by differences in Doctrine or Discipline; but there would not have been the additional provocations of a revolt, and an unfriendly separation on the one side, and a claim of supremacy on the other.

And, accordingly, it was on the very ground of the Reformed being *Heretics* and *Schismatics* that the *secular power* was called in to reduce them by force to submission. Princes were not called on to wage war against *religious error*, merely as such; but they were urged to reduce to obedience those who had *revolted* against the Church to which they were bound to be subject. And thus religious wars, and fierce persecutions, and mutual hatred were introduced, far beyond what would have been likely to arise if the original independence of numerous Churches had always continued.

When several distinct Churches had been *established in revolt*—the members of them having been compelled to *secede* from the Community they had belonged to, on account of a *disagreement* as to the fundamentals of Christianity—the result was, that the ideas of *distinctness*, and of *disagreement*, often came to be, in some measure, blended together in men's minds. There was a sort of presumption created, that any Churches *independent* of each other may be expected to be at *variance*. That mutual friendly feeling and free inter-communion which prevailed in the earliest ages—when an Ephesian Christian, for instance, going to settle at Corinth, or at any other place where there was a christian Church, and bringing proper testimonials, was at once received as a member of that Church—were much impaired, and sometimes forgotten.

And, moreover, when men had become familiarly *accustomed* to separation, from having been forced into it, they were in danger of becoming *careless* about it, and disposed to think lightly of the sin of Schism.

Something similar takes place in many other cases. For instance, those who have been placed in such circumstances as to make the shedding of blood an unavoidable evil, are in danger of gradually losing their original repugnance to it, and becoming so far hardened, as to think little of sacrificing human life, even *without* necessity.

It is the same in the matter now before us. There is always a danger that *necessary* separations may lead to others not necessary, and may have prepared men's minds to make every little difference, even on points of no vital importance, a ground for setting up new sects. The colour of a Minister's vestment,—the names of the months,—and of the days of the week,—the mode of conducting Church music,—the using or not using of a ring in matrimony,—on these and such like matters, differences of opinion have been made a plea for separation.

Now, it is much less likely that this would have occurred in Churches which had not broken off from any other, but had been all along distinct Communities. For though, in any such Church, differences of opinion on minor points might have arisen, it is likely that men would have agreed to some compromise, rather than occasion hostile divisions.

It is true, indeed, that in almost every question, however insignificant, there is a better and a worse decision; and the decision of each man's own judgment will, of course, appear to himself to be the better. But in matters not essential, it is evidently a duty to yield, or to adopt a compromise, rather than endanger christian concord. For if each person were to draw up what might appear to himself the very best form of Church Government, and the best possible mode of expressing each christian Doctrine, and the most perfect Ritual for divine Worship, and should resolve not to belong to any Church that did not exactly adopt all these in every particular, it is plain that there would be almost as many Sects as families, and that no christian community at all could subsist for a single year.

But, as has been above said, when unfriendly separations had been once begun, through a necessity caused by the obstinate retaining of abuses, causeless divisions often ensued from men's having become familiarised to divisions, and almost entirely regardless of Church-union.

And again, abhorrence of such divisions has led some Christians to adopt the system of making a State and a Church *one Community*, and assigning to the Civil Magistrate the entire control in spiritual matters, and the right of dictating to the consciences of all the citizens. And thus under the name of "making the State religious" and "providing for the greatest good of its subjects," they make Christ's a kingdom of this world.

With this fault, and with the endless divisions which have contributed to cause it, Reformers are often exultingly reproached by the advocates of the system of having one great Church which is to comprehend all Christians, and to dictate to them their faith and practice. See, they say, what are the consequences of once allowing any separation from the Church on any grounds whatever! When you have once begun, you cannot tell where to stop.

Now, in truth, that very Church from which the Reformers revolted, was (as has been above pointed out) the original cause of all these evils. In the first place, by obstinately adhering to an accumulated mass of gross corruptions, it made a thorough reformation necessary. And secondly, by having absorbed into *one* Community a multitude of distinct Churches, it made *separation* a necessary part of *reformation*. And thus it not only *retarded* needful reformations, and made them more *difficult*, but also made them, when they did come, much more *hurtful*, and more exposed to the dangers which are attendant on any great reformation.

As for what are, and are not such essential points as to warrant separation, it would of course be unsuitable to our present purpose to enter on the discussion of such a subject. But every one should be warned, that in each question of the kind that may arise, he is bound to inquire and examine seriously, carefully, and dispassionately; not as if it were merely a matter of taste, fancy, or convenience. We are responsible to God for the exercise of our best discretion in forming a decision. And we are bound in duty to Him, to take care neither to sacrifice the essentials of Christianity for the sake of peace, nor again, lightly and wantonly to cause divisions.

All separation, in short, and all resistance to Church-authority, must be either a *duty* or a *sin*. Which of the two it is, in each particular instance, each must decide according to the best of his judgment; which is, after all, fallible. And in no case are we authorised to pronounce our neighbour guilty of an *unpardonable* sin. But though christian charity requires us to make allowance for those who appear to us blameable, it is no part of charity to confound the distinctions of right and wrong; nor indeed would there be any *room* for the exercise of *charity* in judging of those whom we do not consider to be acting wrongly.

On these and several other important questions connected with religion, some persons are so distrustful of what they call "private judgment,"—that is, the judgment of the generality of men, and of themselves,—that they resolve to renounce altogether the exercise of private judgment on all religious questions, and to submit themselves in every thing to the judgment of their Church. They dwell much on the incompetency of most men to decide rightly on difficult points; and consider that there is a pious humility in determining not to exercise their own judgment at all.

But they quite forget that, in the course they adopt, they do decide on one most important and difficult point. A man who resolves to place himself under a certain guide to be implicitly followed, and decides that such and such a Church is the appointed infallible guide, does decide on his own private judgment, *that one* most important point, which includes in it all other decisions relative to Religion. And if, by his own shewing, he is *unfit to judge* at all, he can have no ground for confidence that he has decided it rightly. And if, accordingly, he will not trust himself to judge even on this point, but resolves to consult his priest, or some other friends, and be led entirely by *their* judgment thereupon, still he does, in thus resolving, exercise his own judgment as to the counsellors he so relies on.

There is no need, therefore, to dispute about the *right*, or about the *duty*, of private judgment. For there is plainly an unavoidable *necessity* of private judgment, on any subject wherein we *take any serious interest*. The responsibility is one which, however unfit we may deem ourselves to bear it, we *cannot* possibly get rid of, in any matter about which we really feel an anxious care. It is in vain to discuss the questions whether we *may*, or whether we *ought*, to exercise private judgment, since we *must* do so, whether we will or no.

That which often misleads men in this matter, is that we *can* refrain from exercising private judgment *on this or that particular point*, by *transferring* our judgment to some other point. For example—A sick man who is conscious of his own want of knowledge of medicine, may refrain from exercising any judgment as to the remedies he should use, and may put himself wholly in the hands of a physician; that is, he *judges* that a physician is needful, and that such and such a practitioner is worthy of confidence. Or, supposing he distrusts his own judgment on this point also, then he consults some friend whom he *judges* to be trustworthy, as to *what* physician he shall employ. In one way, or else in another, he cannot but exercise private judgment. So, also, if a man inherit a great fortune, and have a strong sense of the great responsibility attending it, and of his own unfitness to dispose of his wealth, he may resolve to make it all over to trustees, to distribute in charity at their discretion. He may have judged rightly in so doing; but it is evident he *does* judge, and does exercise an act of ownership once for all, in thus divesting himself of his property. And if he deem himself incompetent even to the task of selecting trustees, and relies on the judgment of some friend as to what persons he shall appoint trustees, still he is exercising his judgment in the selection of that friend. The responsibility is one which he cannot shake off, do what he will.

The man who in the course of God's providence comes into the possession of wealth, is by that providence, entrusted with the stewardship of that wealth, however ill-qualified he may seem, to us, or to himself, for such a charge. And instead of murmuring or wondering at God's dispensations, or trying in vain to shake off the responsibility thus laid on him, he should set himself to do the best he can towards the fulfilment of the duty imposed on him.

And it is the same in all cases. We do and must exercise our judgment, on one point or on another, in all matters except those in which we *take no interest*, and which do not occupy our thoughts. In most of the causes, for instance, which are tried in a court of justice, we do not trouble ourselves to exercise any judgment, if we know or care nothing about either plaintiff or defendant, and feel no interest in the decision.

Accordingly, if any one resolves that he will not exercise any judgment on religious matters, and really does consistently keep to that rule, not deceiving himself (as many do) in the way just above noticed, by judging on one point instead of another, he will find that there is only one possible way of complying with that rule—namely, by *withdrawing his attention* as much as possible from the whole subject, except as far as regards outward forms and observances, and refraining altogether from considering the questions, what the christian Religion is, and whether there is any truth in it.

And there are not a few who really do, in this way, abstain from exercising any judgment at all in religious matters, and are content to do and say just what they have been accustomed to, without any serious reflection on the subject. But even so, they do not escape responsibility. For we are responsible, not only for doing, but also for leaving undone ; else, the servant who hid his Lord's talent in the earth would have escaped condemnation.

Of course it is not meant that on any important point a man ought to make up his mind, unassisted, and without consulting those whom he may consider to be intelligent, and well-informed, and upright advisers. Only, let him not deceive himself by imagining that he *can* forego *all* exercise of his own judgment in any matter about which he has a real and anxious care.

And on the other hand, we should guard against the opposite mistake of supposing that whatever is left to our own *discretion* is, therefore, left to our *caprice*, and may be decided on at random. We may *have a right* to do many things which we should not *be right* in doing. For instance, when any bill is brought into Parliament, each member has an undoubted right to vote for it or against it; but it would be absurd to say that he would *be equally right* in doing either. It is in such cases, and in such alone, that there is room for the exercise of any such quality as good sense, wisdom, discretion, &c. For, in matters quite *indifferent*, there is clearly no exercise of judgment in deciding. Nor, again, is there any room for it in matters that are already decided for us, and in which we have *no choice :* as, for instance, when a Judge has to declare what the law *actually* is on such and such a point. But when a Legislator is called on to decide what the law *ought* to be, and, in short, in every case where we have to decide, and where there may be a better or a worse decision, it is then, and then only, that there is room for the exercise of good sense.

We should keep in mind, then, that as the exercise of our own judgment (in matters in which we feel a deep interest) is, on the one hand, *unavoidable*, so it is, on the other hand, *responsible*. We are bound to use, to the best of our power, such faculties and opportunities as God's providence may have bestowed on us, in judging of any question pertaining to Religion ; and among others, in any question as to separation.

But though, as we have already said, much blame attaches to those who hastily, and on slight grounds, separate from their Church ; a Church, on the other hand, is not exempted from a share of blame, which *narrows* too much its terms of communion. *Some* terms, of course, are indispensable; since persons differing as to the fundamentals of christian Doctrine and Worship cannot possibly be members of the same christian Community. But care should be taken not to go beyond what is necessary. If possible, none should be excluded of those who can join in christian Worship together, and receive instruction together in the essential truths of the Gospel. To multiply Articles of Faith and Ordinances, unnecessarily, manifestly tends to create divisions.

And it is not enough to say that these Articles are, all, such as we are convinced are scriptural, and that none of our Ordinances are contrary to Scripture, and that the scruples of those who object to them are unfounded and frivolous. All this may be true ; and it may be true that those are to blame who on such grounds separate from the Church ; yet this does not clear from blame those who put a stumblingblock in the way of weak brethren by insisting on points that are not essential, and on which persons may differ who are yet capable of worshipping together as Members of the same christian Church. " Him that is weak in the Faith, receive ye, but not to doubtful disputations." (Rom. xiv. 1.)

It is to be observed, however, that when we speak of points that are and that are not "essential," we mean, in this place, essential as terms of *communion*; not, of *salvation*. For there are some points of disagreement which would completely prevent men from being Members of the same Church, though hardly any, of either party, would regard the other as under a fatal error.

For example, there are persons irreconcilably opposed on the subject of Church-endowments. Some of the advocates of what is called "the voluntary system" consider it as not only objectionable, but utterly unlawful, to attend what they call a *hired* Ministry[1]—that is, one maintained by endowments. And the other party, though not holding it absolutely *unlawful* for a Minister to be dependent on the voluntary contributions of his People (since "the labourer is worthy of his hire,") yet consider this so very *undesirable*, that they would feel bound to support and promote the system of endowments. Now these two parties could hardly continue Members of the same Church. And yet neither need regard the other as having abandoned the fundamentals of Christianity.

The same may be said of an irreconcilable disagreement as to the use of *extemporary* prayer, and of stated *forms*, in Public Worship. Some consider the use of any form, even the Lord's Prayer, as not allowable. Others, again, believe that a special promise is made to the "common" prayers of a Congregation who "*agree together* touching something they shall ask in Christ's name;" and that, accordingly, they are bound to pray *together*, (either audibly or mentally,) and not merely to *listen* to the prayers offered up by another. And they hold it to be impossible, in most cases, that a Congregation (at least, the *whole* of it) can so constantly go along with all that is said by an extemporary speaker, as to *accompany*—properly speaking—his prayers; that is, so as not only to *understand* and *approve* what he says, but to make his prayers *their own prayers also* at the moment. These prayers, accordingly, will generally be, they conceive, rather of the character of exhortations addressed to the People by the Minister, than of joint-prayers addressed by the People to God.

Now persons strongly impressed with these opposite notions could not be united in one Church, though they may not regard each other as fatally in error.

It has been above said, that a man is deeply responsible for the sin of Schism, if he should, without evident and strong necessity, separate from his Church. But some have doubted *what* Church it is that has this general claim to his allegiance; whether that which is established by *law*; or that which his *ancestors* formerly belonged to; or that in which he *himself* has been brought up.

As for the first of these, the Religion established by law, has not, on *that* ground, any claim on the conscience. A member, for example, of the Church of England becomes a *dissenter* if he settle in some part of the Empire where some other form of religion is established. But if he is conscientiously a member of his own original Church, and sees no reason to consider it unscriptural, he has no right to forsake it on political grounds.

As for the Church to which one's ancestors may have belonged, no one should think himself bound to investigate obscure and difficult questions of history, and to judge of all the acts of those who founded or reformed his Church, perhaps several centuries ago, in order to decide whether he is permitted, or whether he is bound, to continue in the Church in which he was brought up. If those founders separated unreasonably, *they* indeed were chargeable with the sin of Schism. But it would be to create a fresh Schism, if he were to forsake the Church he was brought up in, not from feeling any objection to its Doctrines or Worship, but merely on the ground that its original formation was not justifiable.

And a like principle is universally recognised in all civil affairs. Else, indeed, the whole World would be filled with perpetual rebellions and civil wars. For example, every one knows that Norway was formerly united, not to Sweden, but to Denmark—that, in like manner, Normandy, and other provinces of France, and also the North American States, formerly belonged to England; and that Ireland at one time consisted of several independent Kingdoms. But if a Norman were to hold that he owed no allegiance to the French Government, or an American to that of the United States, and so on, unless every such separation and annexation could be proved originally justifiable, and if every man were to think himself authorised on such grounds to raise revolt, there would be hardly such a thing as a peaceable Government on Earth.

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[1] More properly called *un*hired; being supported, not like a labourer by the wages of his employer, but by endowments similar to those of many Hospitals, Colleges, &c.

Each man, therefore, owes allegiance, generally, to the Church in which he has been brought up, unless he find this incompatible with his reverence for God's Word, and his obedience to the divine Will.

Independently, however, of any *disagreement*, a separation may take place with the consent of all parties, of one Branch of a Church from the rest, merely from reasons of convenience, and without any interruption of harmony and intercommunion, any more than among the several distinct Churches originally founded by the Apostles. For example, this took place with the American Episcopalian Church, which formerly was a portion of the Church of England. When the American States became politically independent, the inconvenience of having one Church whose members were citizens of different political Communities, was so plain to all parties, that a friendly separation was agreed on. And if this had been done long before, by mutual consent, merely on the ground of the inconvenient *distance* between the two Countries, no one could have had any right to find fault with the measure. For, any union or separation that is made by mutual consent, is evidently a matter which the parties concerned have a full right to determine for themselves.

But difficult questions may arise when both parties do *not* thus agree; those who desire to form themselves into a distinct Church being opposed by the rest. Suppose, for instance, that on the occasion just alluded to, the English Church had refused to consent to the independence of the American, and had insisted on retaining control over them. In any such case, those desiring to secede should, in the first place, satisfy themselves, on careful consideration, that the evils they seek to remedy are not only real, but great, and likely to interfere with the objects for which Churches exist. Next, they should respectfully, and in a spirit of kindness, set forth their reasons, and listen candidly to what may be urged on the opposite side. And if they see no reason to alter their opinion, they should still remonstrate earnestly and perseveringly, before they take the extreme step of seceding without the consent of their brethren.

In these, however, and in all similar matters, it is impossible to lay down rules such as will at once apply to every case that may arise. There must always be room for the exercise of sound judgment and candour, in deciding on each particular question.

There is one principle, however, which should always be kept in mind, and which, obvious as it is, men often lose sight of in practice; namely, that a *necessity* imposed by external circumstances, and for which we are not responsible, will justify, and call for, such measures as *would* be sinful if there were no such necessity. We should be careful, therefore, not to commit either the error of censuring men for doing what would, in ordinary circumstances, be wrong; or the error of supposing ourselves at liberty to do, at any time and under any circumstances, whatever has, in some particular case, been justifiably and rightly done.

In the ordinary affairs of life, this principle is, in general, well understood and acted on. For example, for a number of men, citizens of any State, to assemble, and by their own authority, declare themselves a Senate, and proceed to elect Magistrates, and enact Laws, and establish a Government, would justly be regarded as a most heinous act of rebellion; and all their laws, (however good in themselves,) would be evidently null and void. But if a number of persons were to find themselves wrecked on a desert island, or the sole survivors of a pestilence, or in some other way left to themselves, no one would contend that they were bound thenceforward to live in a state of anarchy, because they had no legitimate Rulers or Laws. They would be authorized, and bound, to agree as well as they could, in establishing some sort of Government. And the Laws and Magistrates thus appointed would have as good a claim to obedience as those of any Country in the World; because it is plainly necessary to human welfare, and agreeable to the divine Will, that men should live under a regular Government. Yet this case would afford no precedent for any persons who should take upon them to break up an existing Community, and to revolt against "the Powers that be."

So also, if the persons thus situated were to find themselves without regularly ordained Clergy, or without any except such as they were fully convinced had abandoned the genuine Doctrines of the Gospel, it would be absurd to suppose it could be the Will of their Heavenly Master, that they should remain for ever destitute of a christian Ministry and Church-ordinances. They would clearly be conforming to the spirit of his injunctions, in forming themselves into a Church, and appointing various Orders of Ministers, selecting the best qualified persons they could find, for each office, and establishing Church-regulations according to the best of their judgment. And the necessity under which they were placed, would justify, and render valid, all their acts and appointments; supposing them always not to be in themselves superstitious or unscriptural. But such a case would afford no fair precedent for persons differently circumstanced, who should take upon themselves, wantonly and without necessity, to ordain Ministers, and set up themselves as a new Church.

So, also, there may be extreme cases of such cruel and intolerable oppression as to justify subjects in revolting against an established Government. But extreme cases do not destroy the authority of a general rule, though they may authorize an exceptional departure from it. And it is undoubtedly true, as a general rule, that we are in duty bound to submit to existing Governments.

Again, if the loyal portion of a garrison were to revolt from a general, who had turned traitor, and was betraying the city into an enemy's hands, so far from being treasonable in thus revolting, they would have been abettors of treason if they had not. And yet the general rule is, that soldiers are bound to obey their commander.

In like manner, submission to Church-authority, and the preservation of Church-union, are the rule; and resistance, or separation, the exception. The burden of proof lies with those who undertake to justify a departure from a rule. And if they do thus justify themselves, their case affords no fair precedent for those who would introduce general discord and confusion.

It is to be observed, however, that when we speak of the general claim to obedience, which the Laws of any Community—civil or ecclesiastical—have on its Members, this does not imply such a blind veneration as should withhold us from seeking any needful amendment. Any one who scorns the absurdity of attributing infallibility to human Beings, would be himself guilty of a still greater absurdity, if, while considering all men as fallible, he should yet act as if they were *in*-fallible, by insisting that all their institutions and regulations should be like the Laws of the Medes and Persians, which could never be changed; and that no one should even inquire whether amendment in any point be possible, and needful. All wanton and hasty changes, indeed, should, in all subjects, be avoided; the presumption being, as has been above said, against every alteration. And a man's veneration for any existing Constitution—whether in Church or in State—may reasonably lead him to deprecate any fundamental change. But the best security against this,—in short, against revolution,—is, the constant correction of abuses, and the introduction of improvements as they are needed. It is the neglect of timely *repairs* (as was remarked above) that makes *rebuilding* necessary.

And, moreover, the amendment of any Law that is faulty, tends (beside the immediate benefit) to increase men's confidence in those that are left unchanged; and in this way contributes to the stability of the whole system. For it creates a presumption that what is left unchanged, is so left for some good and sufficient *reasons*, and not from a mere blind determination against *any* change, whether for the worse or for the better.

Some persons, however, there are, who are far from thinking all existing laws (civil or eclesiastical) faultless; and who, on that ground, hold themselves at liberty to disobey or evade any that they think objectionable. But if these very persons are called on to exert themselves to procure, in a regular way, a remedy for the evil, they will shrink from the trouble, or expense, or odium, they might thus incur for the public good. There are many, for example, who from their disapprobation of the existing revenue laws, or game laws, &c., will violate these without scruple, when they can do so with impunity. But when urged to exert themselves in perseveringly calling the attention of the Legislature to these laws, they will plead that it is no concern of theirs, but only of their Rulers.

And they act in the same way with respect to Church-regulations; disregarding without scruple any that they disapprove; but refusing to take any pains for the regular correction of anything they complain of.

But a truly conscientious and right-minded man will pursue exactly the opposite course. As long as a law *exists*, he will feel bound to obey it, as far as he can with a safe conscience. But if he consider it an *unwise* law, he will exert himself to have it amended by competent authority; or, if necessary, to have some competent authority *appointed* for the purpose of rectifying whatever may be amiss. These exertions may, perhaps, cost him much more trouble and discomfort than he, individually, suffers from the existing state of things. But he will not hesitate to sacrifice his own immediate personal comfort and ease, for the lasting benefit of his Countrymen and fellow-Christians. For a true Christian is most emphatically and pre-eminently public-spirited. "NONE OF US," says the Apostle Paul, "LIVETH UNTO HIMSELF." (Rom. xiv. 7.) And he who is the most sedulously occupied in working out, on Gospel principles, his own salvation, will always be found the most devotedly active in promoting the welfare of his brethren.

END OF DISSERTATION THIRD.

DISSERTATION FOURTH:

EXHIBITING A GENERAL VIEW

OF THE

PROGRESS OF MATHEMATICAL AND PHYSICAL SCIENCE,

SINCE THE REVIVAL OF LETTERS IN EUROPE.

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DISSERTATION FOURTH.

PART FIRST.

In conformity to the plan which has been traced and executed with so much ability in the First Dissertation, I am now to present the reader with an historical sketch of the principal discoveries made in Natural Philosophy, from the revival of letters down to the present time. In entering on this task, and on looking at the instructive but formidable model already set before me, I should experience no small solicitude, did I not trust that the subject of which I am to speak, in order to be interesting, needs only to be treated with clearness and precision. These two requisites I will endeavour to keep steadily in view.

In the order which I am to follow, I shall be guided solely by a regard to the subserviency of one science to the progress of another, and to the consequent priority of the former in the order of regular study. For this reason, the history of the pure Mathematics will be first considered, as that science has been one of the two principal instruments applied by the moderns to the advancement of natural knowledge. The other instrument is Experience; and, therefore, the principles of the inductive method, or of the branch of Logic which teaches the application of experiment and observation to the interpretation of nature, must be the second object of inquiry; and in this article I shall give an account of Bacon's Philosophy, as applied to Physical investigation. After these two sections, which may in some measure be considered as introductory, I am to treat of Natural Philosophy, under the divisions of Mechanics, Astronomy, and Optics. Under the general denomination of Mechanics I include the theory of Motion, as applied not only to solids, but to fluids, both incompressible and elastic. Optics I have placed after Astronomy, because the discoveries in Mechanics have much less affected the progress of the former of these sciences than of the latter. To these will succeed a sixth division, containing the laws of the three unknown substances, if, indeed, they may be called substances,—Heat, Electricity, and Magnetism. These, though very different, agree in some general characters. They permeate all substances, though not with the same facility: and, if other bodies had been formed in the same manner with them, the idea of impenetrability would never have been suggested to the mind. They seem to receive motion, without taking any away from the body which communicates it; so that they can hardly be considered as inert. Two of them, Heat and Electricity, are perceived by the sense of touch; but the impression which they make does not convey an idea of resistance. The third is not perceived by touch; and, therefore, all the three might be denominated impalpable substances. If they have any gravity, it cannot be appreciated; and, for these reasons, had it not too paradoxical an appearance, we might class them together as *material*, but *incorporeal* substances. We know, indeed, nothing of them but as powers, transferable from one body to another; and it is in consequence of this last circumstance alone that they are entitled to the name of substances.

Though the general design of this historical sketch extends from the revival of letters to the beginning of the nineteenth century, I shall, in the present Part, confine myself entirely, as has been done in the first Dissertation, to the period preceding the end of the seventeenth century, or, more precisely, to that preceding the invention of the fluxionary calculus, and the discovery of the principle of gravitation;—one of the most remarkable epochas, without doubt, in the history of human knowledge.

SECTION I.

MATHEMATICS.

1. GEOMETRY.

The great inheritance of mathematical knowledge which the ancients bequeathed to posterity could not, on the revival of learning, be immediately taken possession of, nor could even its existence be discovered, but by degrees. Though the study of the Mathematics had never been entirely abandoned, it had been reduced to matters of very simple and easy comprehension, such as were merely subservient to practice. There had been men who could compute the area of a triangle, draw a meridian line, or even construct a sun-dial, in the worst of times; but between such skill, and the capacity to understand or the taste to relish the demonstrations of Euclid, Apollonius, or Archimedes, there was a great interval, and many difficulties were to be overcome, for which much time, and much subsidiary knowledge, were necessary. The repositories of the ancient treasures were to be opened, and made accessible; the knowledge of the languages was to be acquired; the manuscripts were to be deciphered; and the skill of the grammarian and the critic were to precede, in a certain degree, that of the geometrician or the astronomer. The obligations which we have to those who undertook this laborious and irksome task, and who rescued the ancient books from the prisons to which ignorance and barbarism had condemned them, and from the final destruction by which they must soon have been overtaken, are such as we can never sufficiently acknowledge; and indeed we shall never know even the names of many of the benefactors to whom our thanks are due. In the midst of the wars, the confusion, and bloodshed, which overwhelmed Europe during the middle ages, the religious houses and monasteries afforded to the remains of ancient learning an asylum, which a salutary prejudice forced even the most lawless to respect; and the authors who have given the best account of the revival of letters, agree that it is in a great measure to those establishments that we owe the safety of the books which have kept alive the scientific and literary attainments of Greece and Rome.

The study of the remains of antiquity gradually produced men of taste and intelligence, who were able to correct the faults of the manuscripts they copied, and to explain the difficulties of the authors they translated. Such were Purbach, Regiomontanus, Commandine, Maurolycus, and many others. By their means, the writings of Euclid, Archimedes, Apollonius, Ptolemy, and Pappus, became known and accessible to men of science. Arabia contributed its share towards this great renovation, and from the language of that country was derived the knowledge of many Greek books, of the originals of which, some were not found till long afterwards, and others have never yet been discovered.

In nothing, perhaps, is the inventive and elegant genius of the Greeks better exemplified than in their geometry. The elementary truths of that science were connected by Euclid into one great chain, beginning from the axioms, and extending to the properties of the five regular solids; the whole digested into such admirable order, and explained with such clearness and precision, that no similar work of superior excellence has appeared, even in the present advanced state of mathematical science.

Archimedes had assailed the more difficult problems of geometry, and, by means of the method of Exhaustions, had demonstrated many curious and important theorems with regard to the lengths and areas of curves and the contents of solids. The same great geometer had given a beginning to physico-mathematical science, by investigating several propositions, and resolving several problems in Mechanics and Hydrostatics.

Apollonius had treated of the Conic Sections,—the curves which, after the circle, are the most simple and important in geometry; and, by his elaborate and profound researches, had laid the foundation of discoveries which were to illustrate very distant ages.

Another great invention, the Geometrical Analysis, ascribed very generally to the Platonic school, but most successfully cultivated by the geometer just named, is one of the most ingenious and beautiful contrivances in the Mathematics. It is a method of discovering truth by reasoning concerning things unknown, or propositions merely supposed, as if the one were given, or the other were really true. A quantity that is unknown, is only to be found from the relations which it bears to quantities that are known. By reasoning on these relations, we come at last to some one so simple, that the thing sought is thereby determined. By this analytical process, therefore, the thing required is discovered, and we are at the same time put in possession of an instrument by which new truths may be found out, and which, when skill in using it has been acquired by practice, may be applied to an unlimited extent.

A similar process enables us to discover the demonstrations of propositions, supposed to be true, or, if not true, to discover that they are false.

This method, to the consideration of which we shall again have an opportunity of returning, was perhaps the most valuable part of the ancient Mathematics, inasmuch as a method of discovering truth is more valuable than the truths it has already discovered. Unfortunately, however, the fragments containing this precious remnant had suffered more from the injuries of time than almost any other.

In the fifteenth century, Regiomontanus, already mentioned, is the mathematician who holds the highest rank. To him we owe many translations and commentaries, together with several original and valuable works of his own. Trigonometry, which had never been known to the Greeks as a separate science, and which took that form in Arabia, advanced, in the hands of Regiomontanus, to a great degree of perfection, and approached very near to the condition which it has attained at the present day. He also introduced the use of decimal fractions into arithmetic, and thereby gave to that scale its full extent, and to numerical computation the utmost degree of simplicity and enlargement which it seems capable of attaining.

This eminent man was cut off in the prime of life; and his untimely death, says Mr Smith, amidst innumerable projects for the advancement of science, is even at this day a matter of regret.[1] He was buried in the Pantheon at Rome; and the honours paid to him at his death prove that science had now become a distinction which the great were disposed to recognise.

Werner, who lived in the end of this century, is the first among the moderns who appears to have been acquainted with the geometrical analysis. His writings are very rare, and I have never had an opportunity of examining them. What I here assert is on the authority of Montucla, whose judgment in this matter may be safely relied on, as he has shown, by many instances, that he was well acquainted with the nature of the analysis referred to. It is not a little remarkable that Werner should have understood this subject, when we find many eminent mathematicians, long after his time, entirely unacquainted with it, and continually expressing their astonishment how the ancient geometers found out those simple and elegant constructions and demonstrations, of which they have given so many examples. In the days of Werner there was no ancient book known, except the *Data* of Euclid, from which any information concerning the geometrical analysis could be collected; and it is highly to his credit, that, without any other help, he should have come to the knowledge of a method not a little recondite in its principles, and among the finest inventions either of ancient or of modern science. Werner resolved, by means of it, Archimedes's problem of cutting a sphere into two segments, having a given ratio to one another. He proposed also to translate, from the Arabic, the work of Apollonius, entitled *Sectio Rationis*, rightly judging it to be an elementary work in that analysis, and to come next after the *Data* of Euclid.[2]

Benedetto, an Italian mathematician, appears also to have been very early acquainted with the principles of the same ingenious method, as he published a book on the geometrical analysis at Turin in 1585.

Maurolycus of Messina flourished in the middle of the sixteenth century, and is justly regarded as the first geometer of that age. Beside furnishing many valuable translations and commentaries, he wrote a treatise on the Conic Sections, which is highly esteemed. He endeavoured also to restore the fifth book of the Conics of Apollonius, in which that geometer treated of the *maxima* and *minima* of the conic sections. His writings all indicate a man of clear conceptions, and of a strong understanding; though he is taxed with having dealt in astrological prediction.

In the early part of the seventeenth century, Cavalleri was particularly distinguished, and made an advance in the higher geometry, which occupies the middle place between the discoveries of Archimedes and those of Newton.

For the purpose of determining the lengths and areas of curves, and the contents of solids contained within curve superficies, the ancients had invented a method, to which the name of Exhaustions has been given; and in nothing, perhaps, have they more displayed their powers of mathematical invention.

Whenever it is required to measure the space bounded by curve lines, the length of a curve, or the solid contained within a curve superficies, the investigation does not fall within the range of elementary geometry. Rectilineal figures are compared, on the principle of superposition, by help of the notion of equality which is derived from the coincidence of magnitudes both similar and equal. Two rectangles of equal bases and equal altitudes are held to be equal, because they can perfectly coincide. A rectangle and an oblique angled parallelogram, having equal bases and altitudes, are shown to be equal, because the same triangle, taken from the rectangle on one side, and added to it on the other, converts it into the parallelogram; and thus two magnitudes which are not similar, are shown to have equal areas. In like manner, if a triangle and a parallelogram have the same base and altitude, the triangle is shown to be half the parallelogram; because, if to the triangle there be added another, similar and equal to itself, but in the reverse position, the two together will compose a parallelogram, having the same base and altitude with the given triangle. The same is true of the comparison of all other rectilineal figures; and if the reasoning be carefully analyzed, it will always be found to be reducible to the primitive and original idea of equality, derived from things that coincide or occupy the same space; that is to say, the areas which are proved equal are always such as, by the addition or subtraction of equal and similar parts, may be rendered capable of coinciding with one another.

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[1] *History of Astronomy*, p. 90. Regiomontanus was born in 1436, and died in 1476.

[2] See Montucla, *Histoire des Mathématiques*, vol. I. p. 581.

This principle, which is quite general with respect to rectilineal figures, must fail, when we would compare curvilineal and rectilineal spaces with one another, and make the latter serve as measures of the former; because no addition or subtraction of rectilineal figures can ever produce a figure which is curvilineal. It is possible, indeed, to combine curvilineal figures, so as to produce one that is rectilineal; but this principle is of very limited extent; it led to the quadrature of the *lunulæ* of Hippocrates, but has hardly furnished any other result which can be considered as valuable in science.

In the difficulty to which geometers were thus reduced, it might occur, that by inscribing a rectilineal figure within a curve, and circumscribing another round it, two limits could be obtained, one greater and the other less than the area required. It was also evident, that by increasing the number, and diminishing the sides of those figures, the two limits might be brought continually nearer to one another, and of course nearer to the curvilineal area, which was always intermediate between them. In prosecuting this sort of approximation, a result was at length found out, which must have occasioned no less surprise than delight to the mathematician who first encountered it. The result I mean is, that, when the series of inscribed figures was continually increased, by multiplying the number of the sides, and diminishing their size, there was an assignable *rectilineal* area, to which they continually approached, so as to come nearer it than any difference that could be supposed. The same limit would also be observed to belong to the circumscribed figures, and therefore it could be no other than the curvilineal area required.

It appears to have been to Archimedes that a truth of this sort first occurred, when he found that two-thirds of the rectangle, under the ordinate and abscissa of a parabola, was a limit always greater than the inscribed rectilineal figure, and less than the circumscribed. In some other curves, a similar conclusion was found; and Archimedes contrived to show that it was impossible to suppose that the area of the curve could differ from the said limit, without admitting that the circumscribed figure might become less, or the inscribed figure greater than the curve itself. The method of Exhaustions was the name given to the indirect demonstrations thus formed. Though few things more ingenious than this method have been devised, and though nothing could be more conclusive than the demonstrations resulting from it, yet it laboured under two very considerable defects. In the first place, the process by which the demonstration was obtained was long and difficult; and, in the second place, it was indirect, giving no insight into the principle on which the investigation was founded. Of consequence, it did not enable one to find out similar demonstrations, nor increase one's power of making more discoveries of the same kind. It was a demonstration purely synthetical, and required, as all indirect reasoning must do, that the conclusion should be known before the reasoning is begun. A more compendious, and a more analytical method, was therefore much to be wished for, and was an improvement which, at a moment when the field of mathematical science was enlarging so fast, seemed particularly to be required.

Cavalleri, born at Milan in the year 1598, is the person by whom this great improvement was made. The principle on which he proceeded was, that areas may be considered as made up of an infinite number of parallel lines; solids of an infinite number of parallel planes; and even lines themselves, whether curve or straight, of an infinite number of points. The cubature of a solid being thus reduced to the summation of a series of planes, and the quadrature of a curve to the summation of a series of ordinates, each of the investigations was reduced to something more simple. It added to this simplicity not a little, that the sums of series are often more easily found when the number of terms is infinitely great, than when it is finite, and actually assigned.

It appears that a tract on Stereometry, written by Kepler, whose name will hereafter be often mentioned, first led Cavalleri to take this view of geometrical magnitudes. In that tract, which was published in 1615, the measurement of many solids was proposed, which had not before fallen under the consideration of mathematicians. Such, for example, was that of the solids generated by the revolution of a curve, not about its axis, but about any line whatsoever. Solids of that kind, on account of their affinity with the figure of casks, and vessels actually employed for containing liquids, appeared to Kepler to offer both curious and useful subjects of investigation. There were no less than eighty-four such solids, which he proposed for the consideration of mathematicians. He was, however, himself unequal to the task of resolving any but a small number of the simplest of these problems. In these solutions, he was bold enough to introduce into geometry, for the first time, the idea of infinitely great and infinitely small quantities; and by this apparent departure from the rigour of the science, he rendered it in fact a most essential service. Kepler conceived a circle to be composed of an infinite number of triangles, having their common vertex in the centre of the circle, and their infinitely small bases in the circumference. It is to be remarked, that Galileo had also introduced the notion of infinitely small quantities, in his first dialogue *De Mechanica*, where he treats of a cylinder cut out of a hemisphere; and he has done the same in treating of the acceleration of falling bodies. Cavalleri was the friend and disciple of Galileo, but much more profound in the Mathematics. In his hands the idea took a more regular and systematic form, and was explained in his work on Indivisibles, published in 1635.

The rule for summing an infinite series of terms in arithmetical progression had been long known, and the application of it to find the area of a triangle, according to the method of indivisibles, was a matter of no difficulty. The next step was, supposing a series of lines in arithmetical progression, and squares to be described on each of them, to find what ratio the sum of all these squares bears to the greatest square, taken as often as there are terms in the progression. Cavalleri showed, that when the number of terms is infinitely great, the first of these sums is just one-third of the second. This evidently led to the cubature of many solids.

Proceeding one step farther, he sought for the sum of the cubes of the same lines, and found it to be one-fourth of the greatest, taken as often as there are terms; and, continuing this investigation, he was able to assign the sum of the nth powers of a series in arithmetical progression, supposing always the difference of the terms to be infinitely small, and their number to be infinitely great. The number of curious results obtained from these investigations may be easily conceived. It gave, over geometrical problems of the higher class, the same power which the integral calculus, or the inverse method of fluxions does, in the case when the exponent of the variable quantity is an integer. The method of indivisibles, however, was not without difficulties, and could not but be liable to objection, with those accustomed to the rigorous exactness of the ancient geometry. In strictness, lines, however multiplied, can never make an area, or any thing but a line; nor can areas, however they may be added together, compose a solid, or any thing but an area. This is certainly true, and yet the conclusions of Cavalleri, deduced on a contrary supposition, are true also. This happened, because, though the suppositions that a certain series of lines, infinite in number, and contiguous to one another, may compose a certain area, and that another series may compose another area, are neither of them true; yet is it strictly true, that the one of these areas must have to the other the same ratio which the sum of the one series of lines has to the sum of the other series. Thus, it is the ratios of the areas, and not the areas absolutely considered, which are determined by the reasonings of Cavalleri; and that this determination of their ratios is quite accurate, can very readily be demonstrated by the method of exhaustions.

The method of indivisibles, from the great facility with which it could be managed, furnished a most ready method of ascertaining the ratios of areas and solids to one another, and, therefore, scarcely seems to deserve the epithet which Newton himself bestows upon it, of involving in its conceptions something harsh, (*durum*) and not easy to be admitted. It was the doctrine of infinitely small quantities carried to the extreme, and gave at once the result of an infinite series of successive approximations. Nothing, perhaps, more ingenious, and certainly nothing more happy, ever was contrived, than to arrive at the conclusion of all these approximations, without going through the approximations themselves. This is the purpose served by introducing into Mathematics the consideration of quantities infinitely small in size, and infinitely great in number; ideas which, however inaccurate they may seem, yet, when carefully and analogically reasoned upon, have never led into error.

Geometry owes to Cavalleri, not only the general method just described, but many particular theorems, which that method was the instrument of discovering. Among these is the very remarkable proposition, *that as four right angles, to the excess of the three angles of any spherical triangle, above two right angles, so is the superficies of the hemisphere to the area of the triangle.* At that time, however, science was advancing so fast, and the human mind was everywhere expanding itself with so much energy, that the same discovery was likely to be made by more individuals than one at the same time. It was not known in Italy in 1632, when this determination of the area of a spherical triangle was given by Cavalleri, that it had been published three years before by Albert Girard, a mathematician of the Low Countries, of whose inventive powers we shall soon have more occasion to speak.

The Cycloid afforded a number of problems, well calculated to exercise the proficients in the geometry of indivisibles, or of infinites. It is the curve described by a point in the circumference of a circle, while the circle itself rolls in a straight line along a plane. It is not quite certain when this curve, so remarkable for its curious properties, and for the place which it occupies in the history of geometry, first drew the attention of mathematicians. In the year 1639, Galileo informed his friend Torricelli, that, forty years before that time, he had thought of this curve, on account of its shape, and the graceful form it would give to arches in architecture. The same philosopher had endeavoured to find the area of the cycloid; but though he was one of those who first introduced the consideration of infinites into geometry, he was not expert enough in the use of that doctrine, to be able to resolve this problem. It is still more extraordinary, that the same problem proved too difficult for Cavalleri, though he certainly was in complete possession of the principles by which it was to be resolved. It is, however, not easy to determine whether it be to Torricelli, the scholar of Cavalleri, and his successor in genius and talents, or to Roberval, a French mathematician of the same period, and a man also of great originality and invention, that science is indebted for the first quadrature of the cycloid, or the proof that its area is three times that of its generating circle. Both these mathematicians laid claim to it. The French and Italians each took the part of their own countryman; and in their zeal have so perplexed the question, that it is hard to say on which side the truth is to be found. Torricelli, however, was a man of a mild, amiable, and candid disposition; Roberval of a temper irritable, violent, and envious; so that, in as far as the testimony of the individuals themselves is concerned, there is no doubt which ought to preponderate. They had both the skill and talent which fitted them for this, or even for more difficult researches.

The other properties of this curve, those that respect its tangents, its length, its curvature, &c. exercised the ingenuity, not only of the geometers just mentioned, but of Wren, Wallis, Huygens, and, even after the invention of the integral calculus, of Newton, Leibnitz, and Bernoulli.

Roberval also improved the method of quadratures invented by Cavalleri, and extended his solutions to the case, when the powers of the terms in the arithmetical progression of which the sum was to be found were fractional; and

Wallis added the case when they were negative. Fermat, who, in his inventive resources, as well as in the correctness of his mathematical taste,[1] yielded to none of his contemporaries, applied the consideration of infinitely small quantities to determine the *maxima* and *minima* of the ordinates of curves, as also their tangents. Barrow, somewhat later, did the same in England. Afterwards the geometry of infinites fell into the hands of Leibnitz and Newton, and acquired that new character which marks so distinguished an era in the mathematical sciences.

2. ALGEBRA.

It was not from Greece alone that the light proceeded which dispelled the darkness of the middle ages; for, with the first dawn of that light, a mathematical science, of a name and character unknown to the geometers of antiquity, was received in Europe from Arabia. As early as the beginning of the thirteenth century, Leonardo, a merchant of Pisa, having made frequent visits to the East, in the course of commercial adventure, returned to Italy enriched by the traffic, and instructed by the science of those countries. He brought with him the knowledge of Algebra; and a late writer quotes a manuscript of his, bearing the date of 1202, and another that of 1228.[2] The importation of algebra into Europe is thus carried back nearly 200 years farther than has generally been supposed; for Leonardo has been represented as flourishing in the end of the fourteenth century, instead of the very beginning of the thirteenth. It appears, by an extract from his manuscript, published by the above author, that his knowledge of algebra extended as far as quadratic equations. The language was very imperfect, corresponding to the infancy of the science; the quantities and the operations being expressed in words, with the help only of a few abbreviations. The rule for resolving quadratics by completing the square, is demonstrated geometrically.

Though algebra was brought into Europe from Arabia, it is by no means certain that this last is its native country. There is, indeed, reason to think that its invention must be sought for much farther to the East, and probably not nearer than Indostan. We are assured by the Arabian writers, that Mahomet Ben Musa of Chorasan, distinguished for his mathematical knowledge, travelled, about the year 959, into India, for the purpose of receiving further instruction in the science which he cultivated. It is likewise certain, that some books, which have lately been brought from India into this country, treat of algebra in a manner that has every appearance of originality, or at least of being derived from no source with which we are at all acquainted.

Before the time of Leonardo of Pisa, an important acquisition, also from the East, had greatly improved the science of arithmetic. This was the use of the Arabic notation, and the contrivance of making the same character change its signification, according to a fixed rule, when it changed its position, being increased tenfold for every place that it advanced towards the left. The knowledge of this simple but refined artifice was learned from the Moors by Gerbert, a monk of the Low Countries, in the tenth century, and by him made known in Europe. Gerbert was afterwards Pope, by the name of Silvester the Second, but from that high dignity derived much less glory than from having instructed his countrymen in the decimal notation.

The writings of Leonardo, above mentioned, have remained in manuscript; and the first printed book in algebra is that of Lucas de Burgo, a Franciscan, who, towards the end of the fifteenth century, travelled, like Leonardo, into the East, and was there instructed in the principles of algebra. The characters employed in his work, as in those of Leonardo, are mere abbreviations of words. The letters *p* and *m* denote *plus* and *minus;* and the rule is laid down, that, in multiplication, *plus* into *minus* gives *minus*, but *minus* into *minus* gives *plus*. Thus the first appearance of algebra is merely that of a system of short-hand writing, or an abbreviation of common language, applied to the solution of arithmetical problems. It was a contrivance merely to save trouble; and yet to this contrivance we are indebted for the most philosophical and refined art which men have yet employed for the expression of their thoughts. This scientific language, therefore, like those in common use, has grown up slowly, from a very weak and imperfect state, till it has reached the condition in which it is now found.

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[1] He also was very skilful in the geometric analysis, and seems to have more thoroughly imbibed the spirit of that ingenious invention than any of the moderns before Halley.

[2] M. Cossali of Pisa, in a tract on the Origin of Algebra, 1797.

Though in all this the moderns received none of their information from the Greeks, yet a work in the Greek language, treating of arithmetical questions, in a manner that may be accounted algebraic, was discovered in the course of the next century, and given to the world, in a Latin translation, by Xylander, in 1575. This is the work of Diophantus of Alexandria, who had composed thirteen books of Arithmetical Questions, and is supposed to have flourished about 150 years after the Christian era. The questions he resolves are often of considerable difficulty; and a great deal of address is displayed in stating them, so as to bring out equations of such a form as to involve only one power of the unknown quantity. The expression is that of common language, abbreviated and assisted by a few symbols. The investigations do not extend beyond quadratic equations; they are, however, extremely ingenious, and prove the author to have been a man of talent, though the instrument he worked with was weak and imperfect.

The name of Cardan is famous in the history of algebra. He was born at Milan in 1501, and was a man in whose character good and ill, strength and weakness, were mixed up in singular profusion. With great talents and industry, he was capricious, insincere, and vain-glorious to excess. Though a man of real science, he professed divination, and was such a believer in the influence of the stars, that he died to accomplish an astrological prediction. He remains, accordingly, a melancholy proof, that there is no folly or weakness too great to be united to high intellectual attainments.

Before his time very little advance had been made in the solution of any equations higher than the second degree; except that, as we are told, about the year 1508, Scipio Ferrei, Professor of Mathematics at Bologna, had found out a rule for resolving one of the cases of cubic equations, which, however, he concealed, or communicated only to a few of his scholars. One of these, Florido, on the strength of the secret he possessed, agreeably to a practice then common among mathematicians, challenged Tartalea of Brescia, to contend with him in the solution of algebraic problems. Florido had at first the advantage; but Tartalea, being a man of ingenuity, soon discovered his rule, and also another much more general, in consequence of which he came off at last victorious. By the report of this victory, the curiosity of Cardan was strongly excited; for, though he was himself much versed in the Mathematics, he had not been able to discover a method of resolving equations higher than the second degree. By the most earnest and importunate solicitation, he wrung from Tartalea the secret of his rules, but not till he had bound himself, by promises and oaths, never to divulge them. Tartalea did not communicate the demonstrations, which, however, Cardan soon found out, and extended, in a very ingenious and systematic manner, to all cubic equations whatsoever. Thus possessed of an important discovery, which was at least in a great part his own, he soon forgot his promises to Tartalea, and published the whole in 1545, not concealing, however, what he owed to the latter. Though a proceeding so directly contrary to an express stipulation cannot be defended, one does not much regret the disappointment of any man who would make a mystery of knowledge, or keep his discoveries a secret, for purposes merely selfish.

Thus was first published the rule which still bears the name of Cardan, and which, at this day, marks a point in the progress of algebraic investigation, which all the efforts of succeeding analysts have hardly been able to go beyond. As to the general doctrine of equations, it appears that Cardan was acquainted both with the negative and positive roots, the former of which he called by the name of false roots. He also knew that the number of positive, or, as he called them, true roots, is equal to the number of the changes of the signs of the terms; and that the coëfficient of the second term is the difference between the sum of the true and the false roots. He also had perceived the difficulty of that case of cubic equations, which cannot be reduced to his own rule. He was not able to overcome the difficulty, but showed how, in all cases, an approximation to the roots might be obtained.

There is the more merit in these discoveries, that the language of algebra still remained very imperfect, and consisted merely of abbreviations of words. Mathematicians were then in the practice of putting their rules into verse. Cardan has given his a poetical dress, in which, as may be supposed, they are very awkward and obscure; for whatever assistance in this way is given to the memory, must be entirely at the expense of the understanding. It is, at the same time, a proof that the language of algebra was very imperfect. Nobody now thinks of translating an algebraic formula into verse; because, if one has acquired any familiarity with the language of the science, the formula will be more easily remembered than any thing that can be substituted in its room.

Italy was not the only country into which the algebraic analysis had by this time found its way: in Germany it had also made considerable progress; and Stiphelius, in a book of algebra, published at Nuremberg in 1544, employed the same numeral exponents of powers, both positive and negative, which we now use, as far as integer numbers are concerned; but he did not carry the solution of equations farther than the second degree. He introduced the same characters for *plus* and *minus* which are at present employed.

Robert Recorde, an English mathematician, published about this time, or a few years later, the first English treatise on Algebra, and he there introduced the same sign of equality which is now in use.

The properties of algebraic equations were discovered, however, very slowly. Pelitarius, a French mathematician, in a treatise which bears the date of 1558, is the first who observed that the root of an equation is a divisor of the last term; and he remarked also this curious property of numbers, that the sum of the cubes of the natural numbers is the square of the sum of the numbers themselves.

The knowledge of the solution of cubic equations was still confined to Italy. Bombelli, a mathematician of that country, gave a regular treatise on Algebra, and considered, with very particular attention, the irreducible case of Cardan's rule. He was the first who made the remark, that the problems belonging to that case can always be resolved by the trisection of an arch.[1]

Vieta was a very learned man, and an excellent mathematician, remarkable both for industry and invention. He was the first who employed letters to denote the known as well as the unknown quantities; so that it was with him that the language of algebra first became capable of expressing general truths, and attained to that extension which has since rendered it such a powerful instrument of investigation. He has also given new demonstrations of the rule for resolving cubic, and even biquadratic equations. He also discovered the relation between the roots of an equation of any degree, and the coëfficients of its terms, though only in the case where none of the terms are wanting, and where all the roots are real or positive. It is, indeed, extremely curious to remark, how gradually the truths of this sort came in sight. This proposition belonged to a general truth, the greater part of which remained yet to be discovered. Vieta's treatises were originally published about the year 1600, and were afterwards collected into one volume by Schooten, in 1646.

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[1] A passage in Bombelli's book, relative to the algebra of India, has become more interesting, from the information concerning the science of that country, which has reached Europe within the last twenty years. He tells us, that he had seen in the Vatican library, a manuscript of a certain Diophantus, a Greek author, which he admired so much, that he had formed the design of translating it. He adds, that in this manuscript he had found the Indian authors often quoted; from which it appeared that algebra was known to the Indians before it was known to the Arabians. Nothing, however, of all this is to be found in the work of Diophantus, which was published about three years after the time when Bombelli wrote. As it is, at the same time, impossible that he could be so much mistaken about a manuscript which he had particularly examined, this passage remains a mystery, which those who are curious about the ancient history of science would be very glad to have unravelled. See HUTTON's *History of Algebra.*

In speaking of this illustrious man, Vieta, we must not omit his improvements in trigonometry, and still less his treatise on Angular Sections, which was a most important application of algebra to investigate the theorems, and resolve the problems of geometry. He also restored some of the books of Apollonius, in a manner highly creditable to his own ingenuity, but not perfectly in the taste of the Greek geometry; because, though the constructions are elegant, the demonstrations are all synthetical.

About the same period, algebra became greatly indebted to Albert Girard, a Flemish mathematician, whose principal work, *Invention Nouvelle en Algèbre*, was printed in 1669. This ingenious author perceived a greater extent, but not yet the whole of the truth, partially discovered by Vieta, viz. the successive formation of the coëfficients of an equation from the sum of the roots; the sum of their products taken two and two; the same taken three and three, &c. whether the roots be positive or negative. He appears also to have been the first who understood the use of negative roots in the solution of geometrical problems, and is the author of the figurative expression, which gives to negative quantities the name of *quantities less than nothing;* a phrase that has been severely censured by those who forget that there are correct ideas, which correct language can hardly be made to express. The same mathematician conceived the notion of imaginary roots, and showed that the number of the roots of an equation could not exceed the exponent of the highest power of the unknown quantity. He was also in possession of the very refined and difficult rule, which forms the sums of the powers of the roots of an equation from the coëfficients of its terms. This is the greatest list of discoveries which the history of any algebraist could yet furnish.

The person next in order, as an inventor in algebra, is Thomas Harriot, an English mathematician, whose book, *Artis Analyticæ Praxis*, was published after his death, in 1631. This book contains the genesis of all equations, by the continued multiplication of simple equations; that is to say, it explains the truth in its full extent, to which Vieta and Girard had been approximating. By Harriot also, the method of extracting the roots of equations was greatly improved; the smaller letters of the alphabet, instead of the capital letters employed by Vieta, were introduced; and by this improvement, trifling, indeed, compared with the rest, the form and exterior of algebraic expression were brought nearer to those which are now in use.

I have been the more careful to note very particularly the degrees by which the properties of equations were thus unfolded, because I think it forms an instance hardly paralleled in science, where a succession of able men, without going wrong, advanced, nevertheless, so slowly in the discovery of a truth which, when known, does not seem to be of a very hidden and abstruse nature. Their slow progress arose from this, that they worked with an instrument, the use of which they did not fully comprehend, and employed a language which expressed more than they were prepared to understand;—a language which, under the notion, first of negative and then of imaginary quantities, seemed to involve such mysteries as the accuracy of mathematical science must necessarily refuse to admit.

The distinguished author of whom I have just been speaking was born at Oxford in 1560. He was employed in the second expedition sent out by Sir Walter Raleigh to Virginia, and on his return published an account of that country. He afterwards devoted himself entirely to the study of the Mathematics; and it appears from some of his manuscripts, lately discovered, that he observed the spots of the sun as early as December 1610, not more than a month later than Galileo. He also made observations on Jupiter's satellites, and on the comets of 1607 and of 1618.[1]

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[1] The manuscripts which contain these observations, and probably many other things of great interest, are preserved in the collection of the Earl of Egremont, having come into the possession of his family from Henry Percy, Earl of Northumberland, a most liberal patron of science, with whom Harriot appears to have chiefly lived after his return from Virginia.

The succession of discoveries above related brought the algebraic analysis, abstractly considered, into a state of perfection little short of that which it has attained at the present moment. It was thus prepared for the step which was about to be taken by Descartes, and which forms one of the most important epochas in the history of the mathematical sciences. This was the application of the algebraic analysis, to define the nature, and investigate the properties, of curve lines, and, consequently, to represent the notion of variable quantity. It is often said that Descartes was the first who applied algebra to geometry; but this is inaccurate; for such applications had been made before, particularly by Vieta, in his treatise on Angular Sections. The invention just mentioned is the undisputed property of Descartes, and opened up vast fields of discovery for those who were to come after him.

The work in which this was contained is a tract of no more than 106 quarto pages; and there is probably no book of the same size which has conferred so much and so just celebrity on its author. It was first published in 1637.

In the first of the three books into which the tract just mentioned is divided, the author begins with the consideration of such geometrical problems as may be resolved by circles and straight lines; and explains the method of constructing algebraic formulas, or of translating a truth from the language of algebra into that of geometry. He then proceeds to the consideration of the problem, known among the ancients by the name of the *locus ad quatuor rectas*, and treated of by Apollonius and Pappus. The algebraic analysis afforded a method of resolving this problem in its full extent; and the consideration of it is again resumed in the second book. The thing required is, to find the locus of a point, from which, if perpendiculars be drawn to four lines given in position, a given function of these perpendiculars, in which the variable quantities are only of two dimensions, shall be always of the same magnitude.[1] Descartes shows the locus, on this hypothesis, to be always a conic section; and he distinguishes the cases in which it is a circle, an ellipsis, a parabola, or a hyperbola. It was an instance of the most extensive investigation which had yet been undertaken in geometry, though, to render it a complete solution of the problem, much more detail was doubtless necessary. The investigation is extended to the cases where the function, which remains the same, is of three, four, or five dimensions, and where the locus is a line of a higher order, though it may, in certain circumstances, become a conic section. The lines given in position may be more than four, or than any given number; and the lines drawn to them may either be perpendiculars, or lines making given angles with them. The same analysis applies to all the cases; and this problem, therefore, afforded an excellent example of the use of algebra in the investigation of geometrical propositions. The author takes notice of the unwillingness of the ancients to transfer the language of arithmetic into geometry, so that they were forced to have recourse to very circuitous methods of expressing those relations of quantity in which powers beyond the third are introduced. Indeed, to deliver investigation from those modes of expression which involve the composition of ratios, and to substitute in their room the multiplication of the numerical measures, is of itself a very great advantage, arising from the introduction of algebra into geometry.

In this book also, an ingenious method of drawing tangents to curves is proposed by Descartes, as following from his general principles; and it is an invention with which he appears to have been particularly pleased. He says, "Nec verebor dicere, problema hoc non modo eorum quæ scio utilissimum et generalissimum esse, sed etiam eorum quæ in geometria scire unquam desideraverim."[2] This passage is not a little characteristic of Descartes, who was very much disposed to think well of what he had done himself, and even to suppose that it could not easily be rendered more perfect. The truth, however, is, that his method of drawing tangents is extremely operose, and is one of those hasty views which, though ingenious and even profound, require to be vastly simplified, before they can be reduced to practice. Fermat, the rival and sometimes the superior of Descartes, was far more fortunate with regard to this problem, and his method of drawing tangents to curves is the same in effect that has been followed by all the geometers since his time; while that of Descartes, which could only be valued when the other was unknown, has been long since entirely abandoned. The remainder of the second book is occupied with the consideration of the curves, which have been called the Ovals of Descartes, and with some investigations concerning the centres of lenses; the whole indicating the hand of a great master, and deserving the most diligent study of those who would become acquainted with this great enlargement of mathematical science.

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[1] It will easily be perceived, that the word *function* is not contained in the original enunciation of the problem. It is a term but lately introduced into mathematical language, and affords here, as on many other occasions, a more general and more concise expression than could be otherwise obtained.

[2] Cartesii *Geometria*, p. 40.

The third book of the geometry treats of the construction of equations by geometric curves, and it also contains a new method of resolving biquadratic equations.

The leading principles of algebra were now unfolded, and the notation was brought, from a mere contrivance for abridging common language, to a system of symbolical writing, admirably fitted to assist the mind in the exercise of thought.

The happy idea, indeed, of expressing quantity, and the operations on quantity, by conventional symbols, instead of representing the first by real magnitudes, and enunciating the second in words, could not but make a great change on the nature of mathematical investigation. The language of Mathematics, whatever may be its form, must always consist of two parts; the one denoting quantities simply, and the other denoting the manner in which the quantities are combined, or the operations understood to be performed on them. Geometry expresses the first of these by real magnitudes, or by what may be called natural signs; a line by a line, an angle by an angle, an area by an area, &c.; and it describes the latter by words. Algebra, on the other hand, denotes both quantity, and the operations on quantity, by the same system of conventional symbols. Thus, in the expression $x^3 - a\,x^2 + b^3 = o$, the letters a, b, x, denote quantities, but the terms x^3, $a\,x^2$, &c. denote certain operations performed on those quantities, as well as the quantities themselves; x^3 is the quantity x raised to the cube; and ax^2 the same quantity x raised to the square, and then multiplied into a, &c.; the combination, by addition or subtraction, being also expressed by the signs + and —.

Now, it is when applied to this latter purpose that the algebraic language possesses such exclusive excellence. The mere magnitudes themselves might be represented by figures, as in geometry, as well as in any way whatever; but the operations they are to be subjected to, if described in words, must be set before the mind slowly, and in succession, so that the impression is weakened, and the clear apprehension rendered difficult. In the algebraic expression, on the other hand, so much meaning is concentrated into a narrow space, and the impression made by all the parts is so simultaneous, that nothing can be more favourable to the exertion of the reasoning powers, to the continuance of their action, and their security against error. Another advantage resulting from the use of the same notation, consists in the reduction of all the different relations among quantities to the simplest of those relations, that of equality, and the expression of it by equations. This gives a great facility of generalization, and of comparing quantities with one another. A third arises from the substitution of the arithmetical operations of multiplication and division, for the geometrical method of the composition and resolution of ratios. Of the first of these, the idea is so clear, and the work so simple; of the second, the idea is comparatively so obscure, and the process so complex, that the substitution of the former for the latter could not but be accompanied with great advantage. This is, indeed, what constitutes the great difference in practice between the algebraic and the geometric method of treating quantity. When the quantities are of a complex nature, so as to go beyond what in algebra is called the third power, the geometrical expression is so circuitous and involved, that it renders the reasoning most laborious and intricate. The great facility of generalization in algebra, of deducing one thing from another, and of adapting the analysis to every kind of research, whether the quantities be constant or variable, finite or infinite, depends on this principle more than any other. Few of the early algebraists seem to have been aware of these advantages.

The use of the signs *plus* and *minus* has given rise to some dispute. These signs were at first used, the one to denote addition, the other subtraction, and for a long time were applied to no other purpose. But as, in the multiplication of a quantity, consisting of parts connected by those signs, into another quantity similarly composed, it was always found, and could be universally demonstrated, that, in uniting the particular products of which the total was made up, those of which both the factors had the sign *minus* before them, must be added into one sum with those of which all the factors had the sign *plus*, while those of which one of the factors had the sign *plus*, and the other the sign *minus*, must be subtracted from the same,—this general rule came to be more simply expressed by saying, that in multiplication like signs gave *plus*, and that unlike signs gave *minus*.

Hence the signs *plus* and *minus* were considered, not as merely denoting the relation of one quantity to another placed before it, but, by a kind of fiction, they were considered as denoting qualities inherent in the quantities to the names of which they were prefixed. This fiction was found extremely useful, and it was evident that no error could arise from it. It was necessary to have a rule for determining the sign belonging to a product, from the signs of the factors composing that product, independently of every other consideration; and this was precisely the purpose for which the above fiction was introduced. So necessary is this rule in the generalizations of algebra, that we meet with it in Diophantus, notwithstanding the imperfection of the language he employed; for he states, that Λειψις into Λειψις gives ῾Υπαρξις, &c. The reduction, therefore, of the operations on quantity to an arithmetical form, necessarily involves this use of the signs *plus* or *minus*; that is, their application to denote something like absolute qualities in the objects they collect together. The attempts to free algebra from this use of the signs have of course failed, and must ever do so, if we would preserve to that science the extent and facility of its operations.

Even the most scrupulous purist in mathematical language must admit, that no real error is ever introduced by employing the signs in this most abstract sense. If the equation $x^3 + px^2 + qx + r = o$, be said to have one positive and two negative roots, this is certainly as exceptionable an application of the term *negative* as any that can be proposed; yet, in reality, it means nothing but this intelligible and simple truth, that $x^3 + px^2 + qx + r = (x - a)(x + b)(x + c)$; or that the former of these quantities is produced by the multiplication of the three binomial factors, $x - a$, $x + b$, $x + c$. We might say the same nearly as to imaginary roots: they show that the simple factors cannot be found, but that the quadratic factors may be found; and they also point out the means of discovering them.

The aptitude of these same signs to denote contrariety of position among geometric magnitudes, makes the foregoing application of them infinitely more extensive and more indispensable.

From the same source arises the great simplicity introduced into many of the theorems and rules of the mathematical sciences. Thus, the rule for finding the latitude of a place from the sun's meridian altitude, if we employ the signs *plus* and *minus* for indicating the position of the sun and of the place relatively to the equator, is enunciated in one simple proposition, which includes every case, without any thing either complex or ambiguous. But if this is not done,—if the signs *plus* and *minus* are not employed, there must be at least two rules; one when the sun and place are on the same side of the equator, and another when they are on different sides. In the more complicated calculations of spherical trigonometry, this holds still more remarkably. When one would accommodate such rules to those who are unacquainted with the use of the algebraic signs, they are perhaps not to be expressed in less than four, or even six different propositions; whereas, if the use of these signs is supposed, the whole is comprehended in a single sentence. In such cases, it is obvious that both the memory and understanding derive great advantage from the use of the signs, and profit by a simplification, which is the work entirely of the algebraic language, and cannot be imitated by any other.

That I might not interrupt the view of improvements so closely connected with one another, I have passed over one of the discoveries, which does the greatest honour to the seventeenth century, and which took place near the beginning of it.

As the accuracy of astronomical observation had been continually advancing, it was necessary that the correctness of trigonometrical calculation, and of course its difficulty, should advance in the same proportion. The signs and tangents of angles could not be expressed with sufficient correctness without decimal fractions, extending to five or six places below unity; and when to three such numbers a fourth proportional was to be found, the work of multiplication and division became extremely laborious. Accordingly, in the end of the sixteenth century, the time and labour consumed in such calculations had become excessive, and were felt as extremely burdensome by the mathematicians and astronomers all over Europe. Napier of Merchiston, whose mind seems to have been peculiarly turned to arithmetical researches, and who was also devoted to the study of astronomy, had early sought for the means of relieving himself and others from this difficulty. He had viewed the subject in a variety of lights, and a number of ingenious devices had occurred to him, by which the tediousness of arithmetical operations might, more or less completely, be avoided. In the course of these attempts, he did not fail to observe, that whenever the numbers to be multiplied or divided were terms of a geometrical progression, the product or the quotient must also be a term of that progression, and must occupy a place in it pointed out by the places of the given numbers, so that it might be found from mere inspection, if the progression were far enough continued. If, for instance, the third term of the progression were to be multiplied by the seventh, the product must be the tenth; and if the twelfth were to be divided by the fourth, the quotient must be the eighth; so that the multiplication and division of such terms was reduced to the addition and subtraction of the numbers which indicated their places in the progression.

This observation, or one very similar to it, was made by Archimedes, and was employed by that great geometer to convey an idea of a number too vast to be correctly expressed by the arithmetical notation of the Greeks. Thus far, however, there was no difficulty; and the discovery might certainly have been made by men much inferior either to Napier or Archimedes. What remained to be done, what Archimedes did not attempt, and what Napier completely performed, involved two great difficulties. It is plain, that the resource of the geometrical progression was sufficient, when the given numbers were terms of that progression; but if they were not, it did not seem that any advantage could be derived from it. Napier, however, perceived, and it was by no means obvious, that all numbers whatsoever might be inserted in the progression, and have their places assigned in it. After conceiving the possibility of this, the next difficulty was, to discover the principle, and to execute the arithmetical process, by which these places were to be ascertained. It is in these two points that the peculiar merit of his invention consists; and at a period when the nature of series, and when every other resource of which he could avail himself, were so little known, his success argues a depth and originality of thought which, I am persuaded, have rarely been surpassed.

The way in which he satisfied himself that all numbers might be intercalated between the terms of the given progression, and by which he found the places they must occupy, was founded on a most ingenious supposition; that of two points describing two different lines, the one with a constant velocity, and the other with a velocity always increasing in the ratio of the space the point had already gone over: the first of these would generate magnitudes in arithmetical, and the second magnitudes in geometrical progression. It is plain, that all numbers whatsoever would find their places among the magnitudes so generated; and, indeed, this view of the subject is as simple and profound as any which, after two hundred years, has yet presented itself to mathematicians. The mode of deducing the results has been simplified; but it can hardly be said that the principle has been more clearly developed.

I need not observe, that the numbers which indicate the places of the terms of the geometrical progression are called by Napier the *logarithms* of those terms.

Various systems of logarithms, it is evident, may be constructed according to the geometrical progression assumed; and of these, that which was first contrived by Napier, though the simplest, and the foundation of the rest, was not so convenient for the purposes of calculation, as one which soon afterwards occurred, both to himself and his friend Briggs, by whom the actual calculation was performed. The new system of logarithms was an improvement, practically considered; but in as far as it was connected with the principle of the invention, it is only of secondary consideration. The original tables had been also somewhat embarrassed by too close a connection between them and trigonometry. The new tables were free from this inconvenience.

It is probable, however, that the greatest inventor in science was never able to do more than to accelerate the progress of discovery, and to anticipate what time, "the author of authors," would have gradually brought to light. Though logarithms had not been invented by Napier, they would have been discovered in the progress of the algebraic analysis, when the arithmetic of powers and exponents, both integral and fractional, came to be fully understood. The idea of considering all numbers as powers of one given number would then have readily occurred, and the doctrine of series would have greatly facilitated the calculations which it was necessary to undertake. Napier had none of these advantages, and they were all supplied by the resources of his own mind. Indeed, as there never was any invention for which the state of knowledge had less prepared the way, there never was any where more merit fell to the share of the inventor.

His good fortune, also, not less than his great sagacity, may be remarked. Had the invention of logarithms been delayed to the end of the seventeenth century, it would have come about without effort, and would not have conferred on the author the high celebrity which Napier so justly derives from it. In another respect he has also been fortunate. Many inventions have been eclipsed or obscured by new discoveries; or they have been so altered by subsequent improvements, that their original form can hardly be recognised, and, in some instances, has been entirely forgotten. This has almost always happened to the discoveries made at an early period in the progress of science, and before their principles were fully unfolded. It has been quite otherwise with the invention of logarithms, which came out of the hands of the author so perfect, that it has never received but one material improvement,—that which it derived, as has just been said, from the ingenuity of his friend in conjunction with his own. Subsequent improvements in science, instead of offering any thing that could supplant this invention, have only enlarged the circle to which its utility extended. Logarithms have been applied to numberless purposes, which were not thought of at the time of their first construction. Even the sagacity of their author did not see the immense fertility of the principle he had discovered: he calculated his tables merely to facilitate arithmetical, and chiefly trigonometrical computation; and little imagined that he was at the same time constructing a scale whereon to measure the density of the strata of the atmosphere, and the heights of mountains; that he was actually computing the areas and the lengths of innumerable curves, and was preparing for a calculus which was yet to be discovered, many of the most refined and most valuable of its resources. Of Napier, therefore, if of any man, it may safely be pronounced, that his name will never be eclipsed by any one more conspicuous, or his invention superseded by any thing more valuable.

As a geometrician, Napier has left behind him a noble monument in the two trigonometrical theorems, which are known by his name, and which appear first to have been communicated in writing to Cavalleri, who has mentioned them with great eulogy.[1] They are theorems not a little difficult, and of much use, as being particularly adapted to logarithmic calculation. They were published in the *Canon Mirificus Logarithmorum*, at Edinburgh, in 1614.[2]

SECTION II.

EXPERIMENTAL INVESTIGATION.

In this section I shall begin with a short view of the state of Physical Knowledge before the introduction of the Inductive Method; I shall next endeavour to explain that method by an analysis of the *Novum Organum;* and shall then inquire how far the principles established in that work have actually contributed to the advancement of Natural Philosophy.

1. ANCIENT PHYSICS.

Though the phenomena of the material world could not but early excite the curiosity of a being who, like man, receives his strongest impressions from without, yet an accurate knowledge of those phenomena, and their laws, was not to be speedily acquired. The mere extent and variety of the objects were, indeed, such obstacles to that acquisition, as could not be surmounted but in the course of many ages. Man could not at first perceive from what point he must begin his inquiries, in what direction he must carry them on, or by what rules he must be guided. He was like a traveller going forth to explore a vast and unknown wilderness, in which a multitude of great and interesting objects presented themselves on every side, while there was no path for him to follow, no rule to direct his survey, and where the art of observing, and the instruments of observation, must equally be the work of his own invention. In these circumstances, the selection of the objects to be studied was the effect of instinct rather than of reason, or of the passions and emotions, more than of the understanding. When things new, and unlike those which occurred in the course of every day's experience, presented themselves, they excited wonder or surprise, and created an anxiety to discover some principle which might connect them with the appearances commonly observed. About these last, men felt no desire to be further informed; but when the common order of things was violated, and something new or singular was produced, they began to examine into the fact, and attempted to inquire into the cause. Nobody sought to know why a stone fell to the ground, why smoke ascended, or why the stars revolved round the earth. But if a fiery meteor shot across the heavens,—if the flames of a volcano burst forth,—or if an earthquake shook the foundations of the world, terror and curiosity were both awakened; and when the former emotion had subsided, the latter was sure to become active. Thus, to trace a resemblance between the events with which the observer was most familiar, and those to which he was less accustomed, and which had excited his wonder, was the first object of inquiry, and produced the first advances towards generalization and philosophy.[3]

This principle, which it were easy to trace, from tribes the most rude and barbarous, to nations the most highly refined, was what yielded the first attempts toward classification and arrangement, and enabled man, out of individuals subject to perpetual change, to form certain fixed and permanent objects of knowledge,—the species, genera, orders, and classes, into which he has distributed these individuals. By this effort of mental abstraction, he has created to himself a new and intellectual world, free from those changes and vicissitudes to which all material things are destined. This, too, is a work not peculiar to the philosopher, but, in a certain degree, is performed by every man who compares one thing with another, and who employs the terms of ordinary language.

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[1] Wallis, *Opera Math.* tom. II. p. 875.

[2] A reprint of the *Canon Mirificus*, from the original edition, is given in the sixth volume of the great *Thesaurus*, in which Baron Maseres, with his usual zeal and intelligence, has collected and illustrated every thing of importance that has been written on the subject of logarithms. See *Scriptores Logarithmici*, 4to. vol. VI. p. 475.

[3] La maraviglia
Dell' ignoranza é la figlia,
E del sapere
La madre.

Another great branch of knowledge is occupied, not about the mere arrangement and classification of objects, but about events or changes, the laws which those changes observe, and the causes by which they are produced. In a science which treated of events and of change, the nature and properties of motion came of course to be studied, and the ancient philosophers naturally enough began their inquiries with the definition of motion, or the determination of that in which it consists. Aristotle's definition is highly characteristical of the vagueness and obscurity of his physical speculations. He calls motion "the act of a being in power, as far as in power;" words to which it is impossible that any distinct idea can ever have been annexed.

The truth is, however, that the best definition of motion can be of very little service in Physics. Epicurus defined it to be the "change of place," which is, no doubt, the simplest and best definition that can be given; but it must, at the same time, be confessed, that neither he, nor the moderns who have retained his definition, have derived the least advantage from it in their subsequent researches. The properties, or, as they are called, the laws of motion, cannot be derived from mere definition; they must be sought for in experience and observation, and are not to be found without a diligent comparison, and scrupulous examination of facts. Of such an examination, neither Aristotle, nor any other of the ancients, ever conceived the necessity; and hence those laws remained quite unknown throughout all antiquity.

When the laws of motion were unknown, the other parts of Natural Philosophy could make no great advances. Instead of conceiving that there resides in *body* a natural and universal tendency to persevere in the same state, whether of rest or of motion, they believed that terrestrial bodies tended *naturally* either to fall to the ground, or to ascend from it, till they attained their own place; but that, if they were impelled by an oblique force, then their motion became *unnatural* or *violent*, and tended continually to decay. With the heavenly bodies, again, the natural motion was circular and uniform, eternal in its course, but perpetually varying in its direction. Thus, by the distinction between natural and violent motion among the bodies of the earth, and the distinction between what we may call the laws of motion in terrestrial and celestial bodies, the ancients threw into all their reasonings upon this fundamental subject a confusion and perplexity, from which their philosophy never was delivered.

There was, however, one part of physical knowledge in which their endeavours were attended with much better success, and in which they made important discoveries. This was in the branch of mechanics which treats of the action of forces *in equilibrio*, and producing not motion but rest; a subject which may be understood, though the laws of motion are unknown.

The first writer on this subject is Archimedes. He treated of the lever, and of the centre of gravity; and has shown that there will be an equilibrium between two heavy bodies connected by an inflexible rod or lever, when the point in which the lever is supported is so placed between the bodies, that their distances from it are inversely as their weights. Great ingenuity is displayed in this demonstration; and it is remarkable, that the author borrows no principle from experiment, but establishes his conclusion entirely by reasoning *a priori*. He assumes, indeed, that equal bodies, at the ends of the equal arms of a lever, will balance one another; and also, that a cylinder, or parallelopiped of homogeneous matter, will be balanced about its centre of magnitude. These, however, are not inferences from experience; they are, properly speaking, conclusions deduced from the principle of the *sufficient reason.*

The same great geometer gave a beginning to the science of hydrostatics, and discovered the law which determines the loss of weight sustained by a body on being immersed in water, or in any other fluid. His demonstration rests on a principle, which he lays down as a postulatum, that, in water, the parts which are less pressed are always ready to yield in any direction to those that are more pressed; and from this, by the application of mathematical reasoning, the whole theory of floating bodies is derived. The above is the same principle on which the modern writers on hydrostatics proceed; they give it, not as a postulatum, but as constituting the definition of a fluid.

Archimedes, therefore, is the person who first made the application of Mathematics to Natural Philosophy. No individual, perhaps, ever laid the foundation of more great discoveries than that geometer, of whom Wallis has said with so much truth, "Vir stupendæ sagacitatis, qui prima fundamenta posuit inventionum fere omnium, in quibus promovendis ætas nostra gloriatur."

The mechanical inquiries, begun by the geometer of Syracuse, were extended by Ctesibius and Hero; by Anthemius of Tralles; and, lastly, by Pappus Alexandrinus. Ctesibius and Hero were the first who analyzed mechanical engines, reducing them all to combinations of five simple mechanical contrivances, to which they gave the name of Δυναμεις, or Powers, the same which they retain at the present moment.

Even in mechanics, however, the success of these investigations was limited; and failed in those cases where the resolution of forces is necessary, that principle being then entirely unknown. Hence the force necessary to sustain a body on an inclined plane, is incorrectly determined by Pappus, and serves to mark a point to which the mechanical theories of antiquity did not extend.

In another department of physical knowledge, astronomy, the endeavours of the ancients were also accompanied with success. I do not here speak of their astronomical theories, which were, indeed, very defective, but of their discovery of the apparent motions of the heavenly bodies, from the observations begun by Hipparchus, and continued by Ptolemy. In this their success was great; and while the earth was supposed to be at rest, and while the instruments of observation had but a very limited degree of accuracy, a nearer approach to the truth was probably not within the power of human ingenuity. Mathematical reasoning was very skilfully applied; and no men whatever, in the same circumstances, are likely to have performed more than the ancient astronomers. They succeeded, because they were observers, and examined carefully the motions which they treated of. The philosophers, again, who studied the motion of terrestrial bodies, either did not observe at all, or observed so slightly, that they could obtain no accurate knowledge; and in general they knew just enough of the facts to be misled by them.

The opposite ways which the ancients thus took to study the Heavens and the Earth, observing the one, and dreaming, as one may say, over the other, though a striking inconsistency, is not difficult to be explained.

No information at all could be obtained in astronomy, without regular and assiduous observation, and without instruments capable of measuring angles, and of measuring time, either directly or indirectly. The steadiness and regularity of the celestial motions seemed to invite the most scrupulous attention. On the other hand, as terrestrial objects were always at hand, and spontaneously falling under men's view, it seemed unnecessary to take much trouble to become acquainted with them; and as for applying measures, their irregularity appeared to render every idea of such proceeding nugatory. The Aristotelian philosophy particularly favoured this prejudice, by representing the earth, and all things on its surface, as full of irregularity and confusion, while the principles of heat and cold, dryness and moisture, were in a state of perpetual warfare. The unfortunate division of motion into natural and violent, and the distinction, still more unfortunate, between the properties of motion and of body, in the heavens and on the earth, prevented all intercourse between the astronomer and the naturalist, and all transference of the maxims of the one to the speculations of the other.

Though, on account of this inattention to experiment, nothing like the true system of Natural Philosophy was known to the ancients, there are, nevertheless, to be found in their writings many brilliant conceptions, several fortunate conjectures, and gleams of the light which was afterwards to be so generally diffused.

Anaxagoras and Empedocles, for example, taught that the moon shines by light borrowed from the sun, and were led to that opinion, not only from the phases of the moon, but from its light being weak, and unaccompanied by heat. That it was a habitable body, like the earth, appears to be a doctrine as old as Orpheus; some lines, ascribed to that poet, representing the moon as an earth, with mountains and cities on its surface.

Democritus supposed the spots on the face of the moon to arise from the inequalities of the surface, and from the shadows of the more elevated parts projected on the plains. Every one knows how conformable this is to the discoveries made by the telescope.

Plutarch considers the velocity of the moon's motion as the cause which prevents that body from falling to the earth, just as the motion of a stone in a sling prevents it from falling to the ground. The comparison is, in a certain degree, just, and clearly implies the notion of centrifugal force; and gravity may also be considered as pointed at for the cause which gives the moon a tendency to the earth. Here, therefore, a foundation was laid for the true philosophy of the celestial motions; but it was laid without effect. It was merely the conjecture of an ingenious mind, wandering through the regions of possibility, guided by no evidence, and having no principle which could give stability to its opinions. Democritus, and the authors of that physical system which Lucretius has so beautifully illustrated, were still more fortunate in some of their conjectures. They taught that the Milky Way is the light of a great number of small stars, very close to one another; a magnificent conception, which the latest improvements of the telescope have fully verified. Yet, as if to convince us that they derived this knowledge from no pure or certain source, the same philosophers maintained, that the sun and the moon are bodies no larger than they appear to us to be.

Very just notions concerning comets were entertained by some of the ancients. The Chaldeans considered those bodies as belonging to the same order with the planets; and this was also the opinion of Anaxagoras, Pythagoras, and Democritus. The remark of Seneca on this subject is truly philosophical, and contains a prediction which has been fully accomplished: "Why do we wonder that comets, which are so rare a spectacle in the world, observe laws which to us are yet unknown, and that the beginning and end of motions, so seldom observed, are not yet fully understood?"—*Veniet tempus, quo ista quæ nunc latent, in lucem dies extrahat, et longioris ævi diligentia: ad inquisitionem tantorum ætas una non sufficit. Veniet tempus, quo posteri nostri tam aperta nos nescisse mirentur.*[1]

It was, however, often the fate of such truths to give way to error. The comets, which these ancient philosophers had ranked so justly with the stars, were degraded by Aristotle into meteors floating in the earth's atmosphere; and this was the opinion concerning them which ultimately prevailed.

But, notwithstanding the above, and a few other splendid conceptions which shine through the obscurity of the ancient Physics, the system, taken on the whole, was full of error and inconsistency. Truth and falsehood met almost on terms of equality; the former, separated from its root, experience, found no preference above the latter; to the latter, in fact, it was generally forced to give way, and the dominion of error was finally established.

One ought to listen, therefore, with caution to the encomiums sometimes bestowed on the philosophy of those early ages. If these encomiums respected only the talents, the genius, the taste of the great masters of antiquity, we would subscribe to them without any apprehension of going beyond the truth. But if they extend to the methods of philosophizing, and the discoveries actually made, we must be excused for entering our dissent, and exchanging the language of panegyric for that of apology. The infancy of science could not be the time when its attainments were the highest; and before we suffer ourselves to be guided by the veneration of antiquity, we ought to consider in what real antiquity consists. With regard to the progress of knowledge and improvement, "*we* are more ancient than those who went before us."[1] The human race has now more experience than in the generations that are past, and of course may be expected to have made higher attainments in science and philosophy. Compared with Natural Philosophy, as it now exists, the ancient Physics are rude and imperfect. The speculations contained in them are vague and unsatisfactory, and of little value, but as they elucidate the history of the errors and illusions to which the human mind is subject. Science was not merely stationary, but often retrograde; the earliest opinions were frequently the best; and the reasonings of Democritus and Anaxagoras were in many instances more solid than those of Plato and Aristotle. Extreme credulity disgraced the speculations of men who, however ingenious, were little acquainted with the laws of nature, and unprovided with the great criterion by which the evidence of testimony can alone be examined. Though observations were sometimes made, experiments were never instituted; and philosophers who were little attentive to the facts which spontaneously offered, did not seek to increase their number by artificial combinations. Experience, in those ages, was a light which darted a few tremulous and uncertain rays on some small portions of the field of science; but men had not acquired the power over that light which now enables them to concentrate its beams, and to fix them steadily on whatever object they wish to examine. This power is what distinguishes the modern Physics, and is the cause why later philosophers, without being more ingenious than their predecessors, have been infinitely more successful in the study of nature.

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[1] *Nat. Quæst.* lib. vii. cap. xxv.

2. NOVUM ORGANUM.

The defects which have been ascribed to the ancient Physics were not likely to be corrected in the course of the middle ages. It is true, that during those ages a science of pure experiment had made its appearance in the world, and might have been expected to remedy the greatest of these defects, by turning the attention of philosophers to experience and observation. This effect, however, was far from being immediately produced; and none who professed to be in search of truth ever wandered over the regions of fancy, in paths more devious and eccentric, than the first experimenters in Chemistry. They had become acquainted with a series of facts so unlike to any thing already known, that the ordinary principles of belief were shaken or subverted, and the mind laid open to a degree of credulity far beyond any with which the philosophers of antiquity could be reproached. An unlooked-for extension of human power had taken place; its limits were yet unknown; and the boundary between the possible and the impossible was no longer to be distinguished. The adventurers in an unexplored country, given up to the guidance of imagination, pursued objects which the kindness, no less than the wisdom of nature, has rendered unattainable by man; and in their speculations peopled the air, the earth, and all the elements, with spirits and genii, the invisible agents destined to connect together all the facts which they knew, and all those which they hoped to discover. Chemistry, in this state, might be said to have an elective attraction for all that was most absurd and extravagant in the other parts of knowledge; alchemy was its immediate offspring, and it allied itself in succession with the dreams of the Cabalists, the Rosicrucians, and the Theosophers. Thus a science, founded in experiment, and destined one day to afford such noble examples of its use, exhibited for several ages little else than a series of illusory pursuits, or visionary speculations, while now and then a fact was accidentally discovered.

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[1] Bacon.

Under the influence of these circumstances arose Paracelsus, Van Helmont, Fludd, Cardan, and several others, conspicuous no less for the weakness than the force of their understandings; men who united extreme credulity, the most extravagant pretensions, and the most excessive vanity, with considerable powers of invention, a complete contempt for authority, and a desire to consult experience; but destitute of the judgment, patience, and comprehensive views, without which the responses of that oracle are never to be understood. Though they appealed to experience, and disclaimed subjection to the old legislators of science, they were in too great haste to become legislators themselves, and to deduce an explanation of the whole phenomena of nature from a few facts, observed without accuracy, arranged without skill, and never compared or confronted with one another. Fortunately, however, from the turn which their inquiries had taken, the ill done by them has passed away, and the good has become permanent. The reveries of Paracelsus have disappeared, but his application of Chemistry to Pharmacy has conferred a lasting benefit on the world. The *Archæus* of Van Helmont, and the army of spiritual agents with which the discovery of elastic fluids had filled the imagination of that celebrated empiric, are laughed at, or forgotten; but the fluids which he had the sagacity to distinguish, form, at the present moment, the connecting principles of the new Chemistry.

Earlier than any of the authors just named, but in a great measure under the influence of the same delusions, Roger Bacon appears to have been more fully aware than any of them of the use of experiment, and of mathematical reasoning, in physical and mechanical inquiries. But, in the thirteenth century, an appeal from the authority of the schools, even to nature herself, could not be made with impunity. Bacon, accordingly, incurred the displeasure both of the University and of the Church; and this forms one of his claims to the respect of posterity, as it is but fair to consider persecution inflicted by the ignorant and bigoted as equivalent to praise bestowed by the liberal and enlightened.

Much more recently, Gilbert, in his treatise on the Magnet, had given an example of an experimental inquiry, carried on with more correctness, and more enlarged views, than had been done by any of his predecessors. Nevertheless, in the end of the sixteenth century, it might still be affirmed, that the situation of the great avenue to knowledge was fully understood by none, and that its existence, to the bulk of philosophers, was utterly unknown.

It was about this time that Francis Bacon (Lord Verulam) began to turn his powerful and creative mind to contemplate the state of human knowledge, to mark its imperfections, and to plan its improvement. One of the considerations which appears to have impressed his mind most forcibly, was the vagueness and uncertainty of all the physical speculations then existing, and the entire want of connection between the sciences and the arts.

Though these two things are in their nature so closely united, that the same truth which is a principle in science becomes a rule in art, yet there was at that time hardly any practical improvement which had arisen from a theoretical discovery. The natural alliance between the knowledge and the power of man seemed entirely interrupted; nothing was to be seen of the mutual support which they ought to afford to one another; the improvement of art was left to the slow and precarious operation of chance, and that of science to the collision of opposite opinions.

"But whence," said Bacon, "can arise such vagueness and sterility in all the physical systems which have hitherto existed in the world? It is not certainly from any thing in nature itself; for the steadiness and regularity of the laws by which it is governed, clearly mark them out as objects of certain and precise knowledge. Neither can it arise from any want of ability in those who have pursued such inquiries, many of whom have been men of the highest talent and genius of the ages in which they lived; and it can, therefore, arise from nothing else but the perverseness and insufficiency of the methods that have been pursued. Men have sought to make a world from their own conceptions, and to draw from their own minds all the materials which they employed; but if, instead of doing so, they had consulted experience and observation, they would have had facts, and not opinions, to reason about, and might have ultimately arrived at the knowledge of the laws which govern the material world."

"As things are at present conducted," he adds, "a sudden transition is made from sensible objects and particular facts to general propositions, which are accounted principles, and round which, as round so many fixed poles, disputation and argument continually revolve. From the propositions thus hastily assumed, all things are derived, by a process compendious and precipitate, ill suited to discovery, but wonderfully accommodated to debate. The way that promises success is the reverse of this. It requires that we should generalize slowly, going from particular things to those that are but one step more general; from those to others of still greater extent, and so on to such as are universal. By such means, we may hope to arrive at principles, not vague and obscure, but luminous and well defined, such as nature herself will not refuse to acknowledge."

Before laying down the rules to be observed in this inductive process, Bacon proceeds to enumerate the causes of error,—the *Idols*, as he terms them, in his figurative language, or false divinities, to which the mind had so long been accustomed to bow. He considered this enumeration as the more necessary, that the same idols were likely to return, even after the reformation of science, and to avail themselves of the real discoveries that might have been made, for giving a colour to their deceptions.

These idols he divides into four classes, to which he gives names, fantastical, no doubt, but, at the same time, abundantly significant:

Idola Tribus,	Idols of the Tribe ;
—— Specus,	—— of the Den ;
—— Fori,	—— of the Forum ;
—— Theatri,	—— of the Theatre.

1. The *Idols of the Tribe*, or of the race, are the causes of error founded on human nature in general, or on principles common to all mankind. "The mind," he observes, "is not like a plain mirror, which reflects the images of things exactly as they are; it is like a mirror of an uneven surface, which combines its own figure with the figures of the object it represents."[1]

Among the idols of this class, we may reckon the propensity which there is in all men to find in nature a greater degree of order, simplicity, and regularity, than is actually indicated by observation. Thus, as soon as men perceived the orbits of the planets to return into themselves, they immediately supposed them to be perfect circles, and the motion in those circles to be uniform; and to these hypotheses, so rashly and gratuitously assumed, the astronomers and mathematicians of all antiquity laboured incessantly to reconcile their observations.

The propensity which Bacon has here characterized so well, is the same that has been, since his time, known by the name of the *spirit of system.* The prediction, that the sources of error would return, and were likely to infest science in its most flourishing condition, has been fully verified with respect to this illusion, and in the case of sciences which had no existence at the time when Bacon wrote. When it was ascertained, by observation, that a considerable part of the earth's surface consists of minerals, disposed in horizontal strata, it was immediately concluded, that the whole exterior crust of the earth is composed, or has been composed, of such strata, continued all round without interruption; and on this, as on a certain and general fact, entire theories of the earth have been constructed.

There is no greater enemy which science has to struggle with than this propensity of the mind; and it is a struggle from which science is never likely to be entirely relieved; because, unfortunately, the illusion is founded on the same principle from which our love of knowledge takes its rise.

2. The *Idols of the Den* are those that spring

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[1] *Novum Organum*, lib. i. aph. 41.

from the peculiar character of the individual. Besides the causes of error which are common to all mankind, each individual, according to Bacon, has his own dark cavern or den, into which the light is imperfectly admitted, and in the obscurity of which a tutelary idol lurks, at whose shrine the truth is often sacrificed.

One great and radical distinction in the capacities of men is derived from this, that some minds are best adapted to mark the differences, others to catch the resemblances, of things. Steady and profound understandings are disposed to attend carefully, to proceed slowly, and to examine the most minute differences; while those that are sublime and active are ready to lay hold of the slightest resemblances. Each of these easily runs into excess; the one by catching continually at distinctions, the other at affinities.

The studies, also, to which a man is addicted, have a great effect in influencing his opinions. Bacon complains, that the chemists of his time, from a few experiments with the furnace and the crucible, thought that they were furnished with principles sufficient to explain the structure of the universe; and he censures Aristotle for having depraved his Physics so much with his Dialectics, as to render the former entirely a science of words and controversy. In like manner, he blames a philosopher of his own age, Gilbert, who had studied magnetism to good purpose, for having proceeded to form out of it a general system of philosophy. Such things have occurred in every period of science. Thus, electricity has been applied to explain the motion of the heavenly bodies; and, of late, galvanism and electricity together have been held out as explaining not only the affinities of Chemistry, but the phenomena of gravitation, and the laws of vegetable and animal life. It were a good caution for a man who studies nature, to distrust those things with which he is particularly conversant, and which he is accustomed to contemplate with pleasure.

3. The *Idols of the Forum* are those that arise out of the commerce or intercourse of society, and especially from language, or the means by which men communicate their thoughts to one another.

Men believe that their thoughts govern their words; but it also happens, by a certain kind of reaction, that their words frequently govern their thoughts. This is the more pernicious, that words, being generally the work of the multitude, divide things according to the lines most conspicuous to vulgar apprehensions. Hence, when words are examined, few instances are found in which, if at all abstract, they convey ideas tolerably precise and well defined. For such imperfections there seems to be no remedy, but by having recourse to particular instances, and diligently comparing the meanings of words with the external archetypes from which they are derived.

4. The *Idols of the Theatre* are the last, and are the deceptions which have taken their rise from the systems or dogmas of the different schools of philosophy. In the opinion of Bacon, as many of these systems as had been invented, so many representations of imaginary worlds had been brought upon the stage. Hence the name of *idola theatri.* They do not enter the mind imperceptibly, like the other three; a man must labour to acquire them, and they are often the result of great learning and study.

"Philosophy," said he, "as hitherto pursued, has taken much from a few things, or a little from a great many; and, in both cases, has too narrow a basis to be of much duration or utility." The Aristotelian philosophy is of the latter kind; it has taken its principles from common experience, but without due attention to the evidence or the precise nature of the facts; the philosopher is left to work out the rest from his own invention. Of this kind, called by Bacon the *sophistical,* were almost all the physical systems of antiquity.

When philosophy takes all its principles from a few facts, he calls it *empirical,*—such as was that of Gilbert, and of the chemists.

It should be observed, that Bacon does not charge the Physics of antiquity with being absolutely regardless of experiment. No system, indeed, however fantastical, has ever existed, to which that reproach could be applied in its full extent; because, without some regard to fact, no theory can ever become in the least degree plausible. The fault lies not, therefore, in the absolute rejection of experience, but in the unskilful use of it; in taking up principles lightly from an inaccurate and careless observation of many things; or, if the observations have been more accurate, from those made on a few facts, unwarrantably generalized.

Bacon proceeds to point out the circumstances, in the history of the world, which had hitherto favoured these perverse modes of philosophizing. He observes, that the periods during which science had been cultivated were not many, nor of long duration. They might be reduced to three; the first with the Greeks; the second with the Romans; and the third with the western nations, after the revival of letters. In none of all these periods had much attention been paid to Natural Philosophy, the great parent of the sciences.

With the Greeks, the time was very short during which physical science flourished in any degree. The seven Sages, with the exception of Thales, applied themselves entirely to morals and politics; and in later times, after Socrates had brought down philosophy from the heavens to the earth, the study of nature was generally abandoned. In the Roman republic, the knowledge most cultivated, as might be expected among a martial and ambitious people, was such as had a direct reference to war and politics. During the empire, the introduction and establishment of the Christian religion drew the attention of men to theological studies, and the important interests which were then at stake left but a small share of talent and ability to be occupied in inferior pursuits. The vast hierarchy which assumed the command both of the sword and the sceptre, while it occupied and enslaved the minds of men, looked with suspicion on sciences which could not easily be subjected to its control.

At the time, therefore, when Bacon wrote, it might truly be said, that a small portion even of the learned ages, and of the abilities of learned men, had been dedicated to the study of Natural Philosophy. This served, in his opinion, to account for the imperfect state in which he found human knowledge in general; for he thought it certain, that no part of knowledge could attain much excellence without having its foundation laid in physical science.

He goes on to observe, that the end and object of knowledge had been very generally mistaken; that many, instead of seeking through it to improve the condition of human life, by new inventions and new resources, had aimed only at popular applause, and had satisfied themselves with the knowledge of words more than of things; while others, who were exceptions to this rule, had gone still farther wrong, by directing their pursuits to objects imaginary and unattainable. The alchemists, for example, alternately the dupes of their own credulity and of their own imposture, had amazed and tormented the world with hopes which were never to be realized. Others, if possible more visionary, had promised to prolong life, to extinguish disease and infirmity, and to give man a command over the world of spirits, by means of mystic incantations. " All this," says he, " is the mere boasting of ignorance; for, when the knowledge of nature shall be rightly pursued, it will lead to discoveries that will as far excel the pretended powers of magic, as the real exploits of Cæsar and Alexander exceed the fabulous adventures of Arthur of Britain, or Amadis of Gaul."[1]

Again, the reverence for antiquity, and the authority of great names, have contributed much to retard the progress of science. Indeed, the notion of antiquity which men have taken up seems to be erroneous and inconsistent. It is the duration of the world, or of the human race, as reckoned from the extremity that is past, and not from the point of time which is present, that constitutes the true antiquity to which the advancement of science may be conceived to bear some proportion; and just as we expect more wisdom and experience in an old than in a young man, we may expect more knowledge of nature from the present than from any of the ages that are past.

" It is not to be esteemed a small matter in this estimate, that, by the voyages and travels of these later times, so much more of nature has been discovered than was known at any former period. It would, indeed, be disgraceful to mankind, if, after such tracts of the material world have been laid open, which were unknown in former times,—so many seas traversed,—so many countries explored,—so many stars discovered,—philosophy, or the intelligible world, should be circumscribed by the same boundaries as before."

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[1] *Novum Organum*, lib. i. aph. 87.

Another cause has greatly obstructed the progress of philosophy, viz. that men inquire only into the causes of rare, extraordinary, and great phenomena, without troubling themselves about the explanation of such as are common, and make a part of the general course of nature.[1] It is, however, certain, that no judgment can be formed concerning the extraordinary and singular phenomena of nature, without comparing them with those that are ordinary and frequent.

The laws which are every day in action, are those which it is most important for us to understand; and this is well illustrated by what has happened in the scientific world since the time when Bacon wrote. The simple falling of a stone to the ground has been found to involve principles which are the basis of all we know in mechanical philosophy. Without accurate experiments on the descent of bodies at the surface of the earth, the objections against the earth's motion could not have been answered, the inertia of body would have remained unknown, and the nature of the force which retains the planets in their orbits could never have been investigated. Nothing, therefore, can be more out of its place than the fastidiousness of those philosophers who suppose things to be unworthy of study, because, with respect to ordinary life, they are trivial and unimportant. It is an error of the same sort which leads men to consider experiment, and the actual application of the hands, as unworthy of them, and unbecoming the dignity of science. "There are some," says Bacon, "who, delighting in mere contemplation, are offended with our frequent reference to experiments and operations to be performed by the hand, things which appear to them mean and mechanical; but these men do in fact oppose the attainment of the object they profess to pursue, since the exercise of contemplation, and the construction and invention of experiments, are supported on the same principles, and perfected by the same means."[2]

After these preliminary discussions, the great restorer of philosophy proceeds, in the second book of the *Novum Organum*, to describe and exemplify the nature of the Induction, which he deems essential to the right interpretation of nature.

The first object must be to prepare a history of the phenomena to be explained, in all their modifications and varieties. This history is to comprehend not only all such facts as spontaneously offer themselves, but all the experiments instituted for the sake of discovery, or for any of the purposes of the useful arts. It ought to be composed with great care; the facts accurately related, and distinctly arranged; their authenticity diligently examined; those that rest on doubtful evidence, though not rejected, being noted as uncertain, with the grounds of the judgment so formed. This last is very necessary; for facts often appear incredible, only because we are ill informed, and cease to appear marvellous, when our knowledge is farther extended.

All such facts, however, as appear contrary to the ordinary course of our experience, though thus noted down and preserved, must have no weight allowed them in the first steps of investigation, and are to be used only when the general principle, as it emerges from the inductive process, serves to increase their probability.

This record of facts is what Bacon calls Natural History; and it is material to take notice of the comprehensive sense in which that term is understood through all his writings. According to the arrangement of the sciences, which he has explained in his treatise on the *Advancement of Knowledge*, all learning is classed relatively to the three intellectual faculties of Memory, Reason, and Imagination. Under the first of these divisions is contained all that is merely Narration, or History, of whatever kind it may be. Under the second are contained the different sciences, whether they respect the Intellectual or the Material world. Under the third are comprehended Poetry and the Fine Arts. It is with the first of these classes only that we are at present concerned. The first two divisions of it are Sacred and Civil History, the meaning of which is sufficiently understood. The third division is Natural History, which comprehends the description of the facts relative to inanimate matter, and to all animals, except man. Natural History is again subdivided into three parts: 1. The history of the phenomena of nature, which are uniform; 2. Of the facts which are anomalous or extraordinary; 3. Of the processes in the different arts.

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[1] *Novum Organum*, lib. i. aph. 119.

[2] *Impetus Philosophici*: Opera, p. 681, Franc. ad Mœn. 1665, folio.

We are not to wonder at finding the processes of the arts thus enrolled among the materials of Natural History. The powers which act in the processes of nature and in those of art are precisely the same, and are only directed, in the latter case, by the intention of man, toward particular objects. In art, as Bacon elsewhere observes, man does nothing more than bring things nearer to one another, or carry them farther off; the rest is performed by nature, and, on most occasions, by means of which we are quite ignorant.

Thus, when a man fires a pistol, he does nothing but make a piece of flint approach a plate of hardened steel, with a certain velocity. It is nature that does the rest;—that makes the small red-hot and fluid globules of steel, which the flint had struck off, communicate their fire to the gunpowder, and, by a process but little understood, set loose the elastic fluid contained in it; so that an explosion is produced, and the ball propelled with astonishing velocity. It is obvious that, in this instance, art only gives certain powers of nature a particular direction.

To the rules which have been given from Bacon, for the composition of Natural History, I may be permitted to add this other,—that theoretical language should, as much as possible, be avoided. Appearances ought to be described in terms which involve no opinion with respect to their causes. These last are the objects of separate examination, and will be best understood if the facts are given fairly, without any dependence on what should yet be considered as unknown. This rule is very essential where the facts are in a certain degree complicated; for it is then much easier to describe with a reference to theory than without it. It is only from a skilful physician that you can expect a description of a disease which is not full of opinions concerning its cause. A similar observation might be made with respect to agriculture; and with respect to no science more than geology.

The natural history of any phenomenon, or class of phenomena, being thus prepared, the next object is, by a comparison of the different facts, to find out the cause of the phenomenon, its *form*, in the language of Bacon, or its essence. The form of any quality in body is something convertible with that quality; that is, where it exists, the quality is present, and where the quality is present, the form must be so likewise. Thus, if transparency in bodies be the thing inquired after, the form of it is something in which, wherever it is found, there is transparency; and, *vice versa*, wherever there is transparency, that which we have called the form is likewise present.

The form, then, differs in nothing from the cause; only we apply the word *cause* where it is event or change that is the effect. When the effect or result is a permanent quality, we speak of the form or essence.

Two other objects, subordinate to *forms*, but often essential to the knowledge of them, are also occasionally subjects of investigation. These are the latent process, and the latent schematism; *latens processus, et latens schematismus.* The former is the secret and invisible progress by which sensible changes are brought about, and seems, in Bacon's acceptation, to involve the principle, since called the *law of continuity*, according to which, no change, however small, can be effected but in *time.* To know the relation between the time and the change effected in it, would be to have a perfect knowledge of the latent process. In the firing of a cannon, for example, the succession of events during the short interval between the application of the match and the expulsion of the ball, constitutes a latent process of a very remarkable and complicated nature, which, however, we can now trace with some degree of accuracy. In mechanical operations, we can often follow this process still more completely. When motion is communicated from any body to another, it is distributed through all the parts of that other, by a law quite beyond the reach of sense to perceive directly, but yet subject to investigation, and determined by a principle which, though late in being discovered, is now generally recognised. The applications of this mechanical principle are perhaps the instances in which a latent, and, indeed, a very recondite process, has been most completely analyzed.

The latent schematism is that invisible structure of bodies, on which so many of their properties depend. When we inquire into the constitution of crystals, or into the internal structure of plants, &c. we are examining into the latent schematism. We do the same when we attempt to explain elasticity, magnetism, gravitation, &c. by any peculiar structure of bodies, or any arrangement of the particles of matter.[1]

In order to inquire into the *form* or cause of any thing by induction, having brought together the facts, we are to begin with considering what things are thereby excluded from the number of possible forms. This exclusion is the first part of the process of induction: it confines the field of hypothesis, and brings the true explanation within narrower limits. Thus, if we were inquiring into the quality which is the cause of transparency in bodies; from the fact that the diamond is transparent, we immediately exclude rarity or porosity, as well as fluidity, from those causes, the diamond being a very solid and dense body.

Negative instances, or those where the given *form* is wanting, are also to be collected.

That glass, when pounded, is not transparent, is a negative fact, and of considerable importance when the *form* of transparency is inquired into; also, that collections of vapour, such as clouds and fogs, have not transparency, are negative facts of the same kind. The facts thus collected, both affirmative and negative, may, for the sake of reference, be reduced into tables.

Bacon exemplifies his method on the subject of Heat; and, though his collection of facts be imperfect, his method of treating them is extremely judicious, and the whole disquisition highly interesting.[2] He here proposes, as an experiment, to try the reflection of the heat of opaque bodies.[3] He mentions also the *vitrum calendare*, or thermometer, which was just then coming into use. His reflections, after finishing his enumeration of facts, show how sensible he was of the imperfect state of his own knowledge.[4]

After a great number of exclusions have left but a few principles, common to every case, one of these is to be assumed as the cause; and, by reasoning from it synthetically, we are to try if it will account for the phenomena.

So necessary did this exclusive process appear to Bacon, that he says, "It may perhaps be competent to angels, or superior intelligences, to determine the form or essence directly, by affirmations from the first consideration of the subject. But it is certainly beyond the power of man, to whom it is only given to proceed at first by negatives, and, in the last place, to end in an *affirmative*, after the exclusion of every thing else."[5]

The method of induction, as laid down here, is to be considered as applicable to all investigations where experience is the guide, whether in the moral or natural world. "Some may doubt whether we propose to apply our method of investigation to natural philosophy only, or to other sciences, such as logic, ethics, politics. We answer, that we mean it to be so applied. And as the common logic, which proceeds by the syllogism, belongs not only to natural philosophy, but to all the sciences, so our logic, which proceeds by induction, embraces every thing."[6]

Though this process had been pursued by a person of much inferior penetration and sagacity to Bacon, he could not but have discovered that all facts, even supposing them truly and accurately recorded, are not of equal value in the discovery of truth. Some of them show the thing sought for in its highest degree, some in its lowest; some exhibit it simple and uncombined, in others it appears confused with a variety of circumstances. Some facts are easily interpreted, others are very obscure, and are understood only in consequence of the light thrown on them by the former. This led our author to consider what he calls *Prærogativæ Instantiarum*, the comparative value of facts as means of discovery, or as instruments of investigation. He enumerates twenty-seven different species, and enters at some length into the peculiar properties of each. I must content myself, in this sketch, with describing a few of the most important, subjoining, as illustrations, sometimes the examples which the author himself has given, but more frequently such as have been furnished by later discoveries in science.

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[1] *Novum Organum*, lib. ii. aph. 5, 6, &c.

[2] *Ibid.* aph. 18, 20, &c.

[3] *Ibid.* aph. 11.

[4] *Ibid.* aph. 14.

[5] *Ibid.* lib. ii. aph. 15.

[6] *Ibid.* lib. i. aph. 127.

I. The first place in this classification is assigned to what are called *instantiæ solitariæ*, which are either examples of the same quality existing in two bodies which have nothing in common but that quality, or of a quality differing in two bodies which are in all other respects the same. In the first instance, the bodies differ in all things but one; in the second, they agree in all but one. The *hypotheses* that in either case can be entertained, concerning the cause or *form* of the said quality, are reduced to a small number; for, in the first, they can involve none of the things in which the bodies differ; and, in the second, none of those in which they agree.

Thus, of the cause or *form* of colour now inquired into, *instantiæ solitariæ* are found in crystals, prisms of glass, drops of dew, which occasionally exhibit colour, and yet have nothing in common with the stones, flowers, and metals, which possess colour permanently, except the colour itself. Hence Bacon concludes, that colour is nothing else than a modification of the rays of light, produced, in the first case, by the different degrees of incidence; and, in the second, by the texture or constitution of the surfaces of bodies. He may be considered as very fortunate in fixing on these examples; for it was by means of them that Newton afterwards found out the composition of light.

Of the second kind of *instantiæ solitariæ*, Bacon mentions the white or coloured veins which occur in limestone or marble, and yet hardly differ in substance or in structure from the ground of the stone. He concludes, very justly, from this, that colour has not much to do with the essential properties of body.

II. The *instantiæ migrantes* exhibit some *nature* or property of body, passing from one condition to another, either from less to greater, or from greater to less; arriving nearer perfection in the first case, or verging towards extinction in the second.

Suppose the thing inquired into were the cause of whiteness in bodies; an *instantia migrans* is found in glass, which, when entire, is without colour, but, when pulverized, becomes white. The same is the case with water unbroken, and water dashed into foam. In both cases, the separation into particles produces whiteness. So also the communication of fluidity to metals by the application of heat, and the destruction of that fluidity by the abstraction of heat, are examples of both kinds of the *instantia migrans*. Instances of this kind are very powerful for reducing the cause inquired after into a narrow space, and for removing all the accidental circumstances. It is necessary, however, as Bacon very justly remarks,[1] that we should consider not merely the case when a certain quality is lost, and another produced, but the gradual changes made in those qualities during their migration, viz. the increase of the one, and the corresponding diminution of the other. The quantity which changes proportionally to another, is connected with it either as cause and effect, or as a collateral effect of the same cause. When, again, we find two qualities which do not increase proportionally, they afford a negative instance, and assure us that the two are not connected simply as cause and effect.

The mineral kingdom is the great theatre of the *instantiæ migrantes*, where the same *nature* is seen in all gradations, from the most perfect state, till it become entirely evanescent. Such are the shells which we see so perfect in figure and structure in limestone, and gradually losing themselves in the finer marbles, till they can no longer be distinguished. The use, also, of one such fact to explain or interpret another, is nowhere so well seen as in the history of the mineral kingdom.

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[1] *Novum Organum*, lib. ii. aph. 23.

III. In the third place are the *instantiæ ostensivæ*, which Bacon also calls *elucescentiæ* and *prædominantes*. They are the facts which show some particular *nature* in its highest state of power and energy, when it is either freed from the impediments which usually counteract it, or is itself of such force as entirely to repress those impediments. For as every body is susceptible of many different conditions, and has many different forms combined in it, one of them often confines, depresses, and hides another entirely, so that it is not easily distinguished. There are found, however, some subjects in which the *nature* inquired into is completely displayed, either by the absence of impediments, or by the predominance of its own power.

Bacon instances the thermometer, or *vitrum calendare*, as exhibiting the expansive power of heat, in a manner more distinct and measurable than in common cases. To this example, which is well chosen, the present state of science enables us to add many others.

If the weight of the air were inquired into, the Torricellian experiment, or the barometer, affords an *ostensive instance*, where the circumstance which conceals the weight of the atmosphere in common cases, namely, the pressure of it in all directions, being entirely removed, that weight produces its full effect, and sustains the whole column of mercury in the tube. The barometer affords also an example of the *instantia migrans*, when the change is not total, but only partial or progressive. If it be the weight of the air which supports the mercury in the tube of the barometer, when that weight is diminished, the mercury ought to stand lower. On going to the top of a mountain, the weight of the incumbent air is diminished, because a shorter column of air is to be sustained; the mercury in the barometer ought therefore to sink, and it is found to do so accordingly.

These are instances in which the action of certain principles is rendered visible by the removal of all the opposing forces. One may be given where it is the distinct and decisive nature of the fact which leads to the result.

Suppose it were inquired, whether the present land had ever been covered by the sea. If we look at the stratified form of so large a portion of the earth's surface, we cannot but conclude it to be very probable that such land was formed at the bottom of the sea. But the decisive proof is afforded by the shells and corals, or bodies having the perfect shape of shells and corals, and of other marine exuviæ, which are found imbedded in masses of the most solid rock, and often on the tops of very high mountains. This leaves no doubt of the formation of the land under the sea, though it does not determine whether the land, since its formation, has been elevated to its present height, or the sea depressed to its present level. The decision of that question requires other facts to be consulted.

IV. The *instantia clandestina*, which is, as it were, opposed to the preceding, and shows some power or quality just as it is beginning to exist, and in its weakest state, is often very useful in the generalization of facts. Bacon also gave to this the fanciful name of *instantia crepusculi.*

An example of this may be given from hydrostatics. If the suspension of water in capillary tubes be inquired into, it becomes very useful to view that effect when it is least, or when the tube ceases to be capillary, and becomes a vessel of a large diameter. The column is then reduced to a slender ring of water, which goes all round the vessel; and this, though now so inconsiderable, has the property of being independent of the size of the vessel, so as to be in all cases the same when the materials are the same. As there can be no doubt that this ring proceeds from the attraction of the sides, and of the part immediately above the water, so there can be no doubt that the capillary suspension, in part at least, is derived from the same cause. An effect of the opposite kind takes place when a glass vessel is filled with mercury.

V. Next to these may be placed what are called *instantiæ manipulares*, or collective instances, that is, general facts, or such as comprehend a great number of particular cases. As human knowledge can but seldom reach the most general cause or *form*, such collective instances are often the utmost extent to which our generalization can be carried. They have great value on this account, as they likewise have on account of the assistance which they give to further generalization.

Of this we have a remarkable instance in one of the most important steps ever taken in any part of human knowledge. The laws of Kepler are facts of the kind now treated of, and consist of three general truths, each belonging to the whole planetary system; and it was by means of them that Newton discovered the principle of gravitation. The first is, that the planets all move in elliptical orbits, having the sun for their common focus; the next, that about this focus the *radius vector* of each planet describes equal areas in equal times; the third and last, that the squares of the periodic times of the planets are as the cubes of their mean distances from the sun. The knowledge of each of these was the result of much research, and of the comparison of a vast multitude of observations, insomuch that it may be doubted if ever three truths in science were discovered at the expense of so much labour and patience, or with the exertion of more ingenuity and invention in imagining and combining observations. These discoveries were all made before Bacon wrote, but he is silent concerning them; for the want of mathematical knowledge concealed from his view some of the most splendid and interesting parts of science.

Astronomy is full of such collective instances, and affords them, indeed, of the second and third order, that is to say, two or three times generalized. The astronomer observes nothing but that a certain luminous disk, or perhaps merely a luminous point, is in a certain position, in respect of the planes of the meridian and the horizon, at a certain moment of time. By comparing a number of such observations, he finds that this luminous point moves in a certain plane, with a certain velocity, and performs a revolution in a certain time. Thus, the periodic time of a planet is itself a collective fact, or a single fact expressing the result of many hundred observations. This holds with respect to each planet, and with respect to each element, as it is called, of the planet's orbit, every one of which is a general fact, expressing the result of an indefinite number of particulars. This holds still more remarkably of the inferences which extend to the distances of the planet from the earth, or from the sun. The laws of Kepler are therefore collective facts of the second, or even a higher order; or such as comprehend a great number of general facts, each of which is itself a general fact, including many particulars. It is much to the credit of astronomy, that, in all this process, no degree of truth or certainty is sacrificed; and that the same demonstrative evidence is preserved from the lowest to the highest point. Nothing but the use of mathematical reasoning could secure this advantage to any of the sciences.

VI. In the next place may be ranked the instances which Bacon calls *analogous*, or *parallel*. These consist of facts, between which an analogy or resemblance is visible in some particulars, notwithstanding great diversity in all the rest. Such are the telescope and microscope, in the works of art, compared with the eye in the works of nature. This, indeed, is an analogy which goes much beyond the mere exterior; it extends to the internal structure, and to the principle of action, which is the same in the eye and in the telescope,—to the *latent schematism*, in the language of Bacon, as far as material substance is concerned. It was the experiment of the *camera obscura* which led to the discovery of the formation of the images of external objects in the bottom of the eye by the action of the crystalline lens, and the other humours of which the eye is formed.

Among the instances of conformity, those are the most useful which enable us to compare productions of an unknown formation, with similar productions of which the formation is well understood. Such are basalt, and the other trap rocks, compared with the lava thrown out from volcanoes. They have a structure so exactly similar, that it is hardly possible to doubt that their origin is the same, and that they are both produced by the action of subterraneous fire. There are, however, amid their similarity, some very remarkable differences in the substances which they contain, the trap rocks containing calcareous spar, and the lava never containing any. On the supposition that they are both of igneous origin, is there any circumstance, in the conditions in which heat may have been applied to them, which can account for this difference? Sir James Hall, in a train of most philosophical and happily-contrived experiments, has explained the nature of those conditions, and has shown that the presence of calcareous spar, or the want of it, may arise from the greater or less compression under which the fusion of the basalt was performed. This has served to explain a great difficulty in the history of the mineral kingdom.

Comparative anatomy is full of analogies of this kind, which are most instructive, and useful guides to discovery. It was by remarking in the blood-vessels a contrivance similar to the valves used in hydraulic engines, for preventing the counter-current of a fluid, that Harvey was led to the discovery of the circulation of the blood. The analogies between natural and artificial productions are always highly deserving of notice.

The facts of this class, however, unless the analogy be very close, are apt to mislead, by representing accidental regularity as if it were constant. Of this we have an example in the supposed analogy between the colours in the prismatic spectrum and the divisions of the monochord. The colours in the prismatic spectrum do not occupy the same proportion of it in all cases; the analogy depends on the particular kind of glass, not on any thing that is common to all refraction. The tendency of man to find more order in things than there actually exists, is here to be cautiously watched over.

VII. *Monodic*, or singular facts, are the next in order. They comprehend the instances which are particularly distinguished from all those of the genus or species to which they belong. Such is the sun among the stars, the magnet among stones, mercury among metals, boiling fountains among springs, the elephant among quadrupeds. So also among the planets, Saturn is singular from his ring; the new planets are so likewise from their small size, from being extrazodiacal, &c.

Connected with these are the irregular and deviating instances, in which nature seems to depart from her ordinary course. Earthquakes, extraordinary tempests, years of great scarcity, winters of singular severity, &c. are of this number. All such facts ought to be carefully collected; and there should be added an account of all monstrous productions, and of every thing remarkable for its novelty and its rareness. Here, however, the most severe criticism must be applied; every thing connected with superstition is suspicious, as well as whatever relates to alchemy or magic.

A set of facts, which belongs to this class, consists of the instances in which *stones* have so often of late years been observed to fall from the heavens. Those stones are so unlike other atmospherical productions, and their origin must be so different from that of other minerals, that it is scarcely possible to imagine any thing more anomalous, and more inconsistent with the ordinary course of our experience. Yet the existence of this phenomenon is so well authenticated by testimony, and by the evidence arising from certain physical considerations, that no doubt with respect to it can be entertained, and it must therefore be received, as making a part of the natural history of meteors. But as every fact, or class of facts, which is perfectly singular, must be incapable of explanation, and can only be understood when its resemblance to other things has been discovered; so at present we are unable to assign the cause of these phenomena, and have no right to offer any theory of their origin.

VIII. Another class of facts is composed of what Bacon calls *instantiæ comitatus*, or examples of certain qualities which always accompany one another. Such are flame and heat,—flame being always accompanied by heat, and the same degree of heat in a given substance being always accompanied with flame. So also heat and expansion,—an increase of heat being accompanied with an increase of volume, except in a very few cases, and in circumstances very particular.

The most perfect *instantia comitatus* known, as being without any negative, is that of body and weight. Whatever is impenetrable and inert, is also heavy in a degree proportional to its inertia. To this there is no exception, though we do not perceive the connection as necessary.

Hostile instances, or those of perpetual separation, are the reverse of the former.

Examples of this are found in air, and the other elastic fluids, which cannot have a solid form induced on them by any known means, when not combined with other substances. So also in solids, transparency and malleability are never joined, and appear to be incompatible, though it is not obvious for what reason.

IX. Passing over several classes which seem of inferior importance, we come to the *instantia crucis*, the division of this experimental logic which is most frequently resorted to in the practice of inductive investigation. When, in such an investigation, the understanding is placed in *equilibrio*, as it were, between two or more causes, each of which accounts equally well for the appearances, as far as they are known, nothing remains to be done but to look out for a fact which can be explained by the one of these causes, and not by the other: if such a one can be found, the uncertainty is removed, and the true cause is determined. Such facts perform the office of a cross, erected at the separation of two roads, to direct the traveller which he is to take; and, on this account, Bacon gave them the name of *instantiæ crucis.*

Suppose that the subject inquired into were the motion of the planets, and that the phenomena which first present themselves, or the motion of these bodies in longitude, could be explained equally on the Ptolemaic and the Copernican system, that is, either on the system which makes the earth, or that which makes the sun, the centre of the planetary motions; a cautious philosopher would hesitate about which of the two he should adopt, and notwithstanding that one of them was recommended by its superior simplicity, he might not think himself authorized to give to it a decided preference above the other. If, however, he consider the motion of these bodies in latitude, that is to say, their digressions from the plane of the ecliptic, he will find a set of phenomena which cannot be reconciled with the supposition that the earth is the centre of the planetary motions, but which receive the most simple and satisfactory explanation from supposing that the sun is at rest, and is the centre of those motions. The latter phenomena would therefore serve as *instantiæ crucis*, by which the superior credibility of the Copernican system was fully evinced.

Another example which I shall give of an *instantia crucis* is taken from Chemistry, and is, indeed, one of the most remarkable experiments which has been made in that science.

It is a general fact observed in Chemistry, that metals are always rendered heavier by calcination. When a mass of tin or lead, for instance, is calcined in the fire, though every precaution is taken to prevent any addition from the adhesion of ashes, coals, &c. the absolute weight of the mass is always found to be increased. It was long before the cause of this phenomenon was understood. There might be some heavy substance added, though what it was could not easily be imagined; or some substance might have escaped, which was in its nature light, and possessed a tendency upwards. Other phenomena, into the nature of which it is at present unnecessary to inquire, induced chemists to suppose, that in calcination a certain substance actually escapes, being present in the regulus, but not in the calx of the metal. This substance, to which they gave the name of phlogiston, was probably that which, by its escape, rendered the metal heavier, and must, therefore, be itself endued with absolute levity.

The *instantia crucis* which extricated philosophers from this difficulty, was furnished by an experiment of the celebrated Lavoisier. That excellent chemist included a quantity of tin in a glass retort, hermetically sealed, and accurately weighed together with its contents; he then applied the necessary heat, and when the calcination of the tin was finished, he found the weight of the whole precisely the same as before. This proved that no substance, which was either light or heavy, in a sensible degree, had made its way through the glass. The experiment went still farther. When the retort was cooled and opened, the air rushed in; so that it was evident that a part of the air had disappeared, or had lost its elasticity. On weighing the whole apparatus, it was now found that its weight was increased by ten grains; so that ten grains of air had entered into the retort when it was opened. The calx was next taken out, and weighed separately, and it was found to have become heavier by ten grains precisely. The ten grains of air then which had disappeared, and which had made way for the ten grains that rushed into the retort, had combined with the metal during the process of calcination. The further prosecution of this very decisive experiment led to the knowledge of that species of air which combines with metals when they are calcined. The doctrine of phlogiston was of course exploded, and a creature of the imagination replaced by a real existence.

The principle which conducts to the contrivance of an *experimentum crucis* is not difficult to be understood. Taking either of the hypotheses, its consequences must be attempted to be traced, supposing a different experiment to be made. This must be done with respect to the other hypothesis, and a case will probably at last occur, where the two hypotheses would give different results. The experiment made in those circumstances will furnish an *instantia crucis.*

Thus, if the experiment of calcination be performed in a close vessel, and if phlogiston be the cause of the increase of weight, it must either escape through the vessel, or it must remain in the vessel after separation from the calx. If the former be the case, the apparatus will be increased in weight; if the latter, the phlogiston must make its escape on opening the vessel. If neither of these be the case, it is plain that the theory of phlogiston is insufficient to explain the facts.

The *experimentum crucis* is of such weight in matters of induction, that in all those branches of science where it cannot easily be resorted to, (the circumstances of an experiment being out of our power, and incapable of being varied at pleasure) there is often a great want of conclusive evidence. This holds of agriculture, medicine, political economy, &c. To make one experiment, similar to another in all respects but one, is what the *experimentum crucis*, and, in general, the process of induction, principally requires; but it is what, in the sciences just named, can seldom be accomplished. Hence the great difficulty of separating the causes, and allotting to each its due proportion of the effect. Men deceive themselves in consequence of this continually, and think they are reasoning from fact and experience, when, in reality, they are only reasoning from a mixture of truth and falsehood. The only end answered by facts so incorrectly apprehended, is that of making error more incorrigible.

Of the twenty-seven classes into which *instantiæ* are arranged by the author of the *Novum Organum*, fifteen immediately address themselves to the Understanding; five serve to correct or to inform the Senses; and seven to direct the hand in raising the superstructure of Art on the foundation of Science. The examples given above are from the first of these divisions, and will suffice for a summary. To the five that follow next, the general name of *instantiæ lampadis* is given, from their office of assisting or informing the senses.

Of these the *instantiæ januæ* assist the immediate action of the senses, and especially of sight. The examples quoted by Bacon are the microscope and telescope, (which last he mentions as the invention of Galileo) and he speaks of them with great admiration, but with some doubt of their reality.

The *instantiæ citantes* enable us to perceive things which are in themselves insensible, or not at all the objects of perception. They cite or place things, as it were, before the bar of the senses, and from this analogy to judicial proceedings is derived the name of *instantiæ citantes.* Such, to employ examples which the progress of science has unfolded since the time of Bacon, are the air-pump and the barometer for manifesting the weight and elasticity of air; the measurement of the velocity of light, by means of the eclipses of the satellites of Jupiter, and the aberration of the fixed stars; the experiments in electricity and galvanism, and in the greater part of pneumatic chemistry. In all these instances things are made known which before had entirely escaped the senses.

The *instantiæ viæ* are facts which manifest the continuous progress of nature in her operations. There is a propensity in men to view nature as it were at intervals, or at the ends of fixed periods, without regarding her gradual and unceasing action.[1] The desire of making observation easy is the great source of this propensity. Men wish for knowledge, but would obtain it at the least expense of time and labour. As there is no time, however, at which the hand of nature ceases to work, there ought to be none at which observation ceases to be made.

The *instantiæ persecantes*, or *vellicantes*, are those which force us to attend to things which, from their subtilty and minuteness, escape common observation.

Some of Bacon's remarks on this subtilty are such as would do credit to the most advanced state of science, and show how much his mind was fitted for distinguishing and observing the great and admirable in the works of nature.

The last division contains seven classes, of which I mention only two. The experiments of this division are those most immediately tending to produce the improvement of art from the extension of science. "Now there are," says Bacon, "two ways in which knowledge, even when sound in itself, may fail of becoming a safe guide to the artist; and these are either when it is not sufficiently precise, or when it leads to more complicated means of producing an effect than can be employed in practice. There are therefore two kinds of experiments which are of great value in promoting the alliance between knowledge and power;—those which tend to give accurate and exact measures of objects, and those which disencumber the processes deduced from scientific principles, of all unnecessary operations."

In the *instantiæ radii* we measure objects by lines and angles; in the *instantiæ curriculi*, by time or by motion.

To the former of these classes are to be referred a number of instruments which now constitute the greater part of the apparatus of Natural Philosophy. Though Bacon had a just idea of their utility in general, he was unacquainted with most of them. The most remarkable at present are those that follow.

1. Astronomical instruments, or, more generally, all instruments for measuring lines and angles.

2. Instruments for measuring weight or force; such are the common balance, the hydrostatic balance, the barometer, the instruments used in England by Cavendish, and in France by Coulomb, which measure small and almost insensible actions by the force of torsion.

These last rather belong to the class of the *instantiæ luctæ*, where force is applied as the measure of force, than to the *instantiæ radii*.

3. The thermometer, newly invented in the time of Bacon, and mentioned by him under the name of *Vitrum Calendare*, an instrument to which we owe nearly all the knowledge we have of one of the most powerful agents in nature, viz. Heat.

4. The hygrometer, an instrument for measuring the quantity of humidity contained in the air; and in the construction of which, after repeated failures by the most skilful experimenters, the invention of Professor Leslie now promises success. Almost every one of these instruments, to which several more might be added, has brought in sight a new country, and has enriched science not only with new facts, but with new principles.

Among the remarks of Bacon on the *experimenta radii*, some are very remarkable for the extent of view which they display even in the infancy of physical science. He mentions the forces by which bodies act on one another at a distance, and throws out some hints at the attraction which the heavenly bodies exert on one another.

"Inquirendum est," says he, "si sit vis aliqua magnetica quæ operetur per consensum inter globum terræ et ponderosa, aut inter globum lunæ et aquas maris, aut inter cœlum stellatum et planetas, per quam avocentur et attollantur ad sua apogæa; hæc omnia operantur ad distantias admodum longinquas."[2]

Under the head of the *instantia curriculi*, or the measuring of things by time; after remarking that every change and every motion requires time, and illustrating this by a variety of instances, he has the following very curious anticipation of facts, which appeared then doubtful, but which subsequent discovery has ascertained:

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[1] *Novum Organum*, lib. ii. aph. 41.

[2] *Ibid.* aph. 45.

"The consideration of those things produced in me a doubt altogether astonishing, viz. Whether the face of the serene and starry heavens be seen at the instant it really exists, or not till some time later; and whether there be not, with respect to the heavenly bodies, a true time and an apparent time, no less than a true place and an apparent place, as astronomers say, on account of parallax. For it seems incredible that the *species* or rays of the celestial bodies can pass through the immense interval between them and us in an instant, or that they do not even require some considerable portion of time."[1]

The measurement of the velocity of light, and the wonderful consequences arising from it, are the best commentaries on this passage, and the highest eulogy on its author.

Such were the speculations of Bacon, and the rules he laid down for the conduct of experimental inquiries, before any such inquiries had yet been instituted. The power and compass of a mind which could form such a plan beforehand, and trace not merely the outline, but many of the most minute ramifications, of sciences which did not yet exist, must be an object of admiration to all succeeding ages. He is destined, if indeed any thing in the world be so destined, to remain an *instantia singularis* among men, and as he has had no rival in the times which are past, so is he likely to have none in those which are to come. Before any parallel to him can be found, not only must a man of the same talents be produced, but he must be placed in the same circumstances; the memory of his predecessor must be effaced, and the light of science, after being entirely extinguished, must be again beginning to revive. If a second Bacon is ever to arise, he must be ignorant of the first.

Bacon is often compared with two great men who lived nearly about the same time with himself, and who were both eminent reformers of philosophy, Descartes and Galileo.

Descartes flourished about forty years later than Bacon, but does not seem to have been acquainted with his writings. Like him, however, he was forcibly struck with the defects of the ancient philosophy, and the total inaptitude of the methods which it followed, for all the purposes of physical investigation. Like him, too, he felt himself strongly impelled to undertake the reformation of this erroneous system; but the resemblance between them goes no farther; for it is impossible that two men could pursue the same end by methods more diametrically opposite.

Descartes never proposed to himself any thing which had the least resemblance to induction. He began with establishing principles, and from the existence of the Deity and his perfections, he proposed to deduce the explanation of all the phenomena of the world, by reasoning *a priori.* Instead of proceeding upward from the effect to the cause, he proceeded continually downward from the cause to the effect. It was in this manner that he sought to determine the laws of motion, and of the collision of bodies, in which last all his conclusions were erroneous. From the same source he deduced the existence of a *plenum*, and the continual preservation of the same quantity of motion in the universe; a proposition which, in a certain sense, is true, but in the sense in which he understood it, is altogether false. Reasonings of the kind which he employed may possibly suit, as Bacon observed, with intelligences of a higher order than man, but to his case they are quite inapplicable. Of the fruit of this tree nature has forbidden him to eat, and has ordained that, with the sweat of his brow, and the labour of his hands, he should earn his knowledge as well as his subsistence.

Descartes, however, did not reject experiment altogether, though he assigned it a very subordinate place in his philosophy. By reasoning down from first principles, he tells us that he was always able to discover the effects; but the number of different shapes which those effects might assume was so great, that he could not determine, without having recourse to experiment, which of them nature had preferred to the rest. "We employ experiment," says he, "not as a reason by which any thing is proved, for we wish to deduce effects from their causes, and not conversely causes from their effects. We appeal to experience only, that out of innumerable effects which may be produced from the same cause, we may direct our attention to one rather than another." It is wonderful, that Descartes did not see what a severe censure he was here passing on himself; of how little value the speculations must be that led to conclusions so vague and indefinite; and how much more philosophy is disgraced by affording an explanation of things which *are not*, than by *not* affording an explanation of things which *are*.

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[1] *Novum Organum*, lib. ii. aph. 46.

As a system of philosophy and philosophic investigation, the method of Descartes can, therefore, stand in no comparison with that of Bacon. Yet his Physics contributed to the advancement of science, but did so, much more by that which they demolished, than by that which they built up. In some particular branches the French philosopher far excelled the English. He greatly improved the science of optics, and in the pure mathematics, as has been already shown, he left behind him many marks of a great and original genius. He will, therefore, be always numbered among those who have essentially contributed to the advancement of knowledge, though nothing could be more perverse than his method of philosophizing, and nothing more likely to impede the progress of science, had not an impulse been at that time given to the human mind which nothing could resist.

Galileo, the other rival and contemporary of Bacon, is, in truth, one of those to whom human knowledge is under the greatest obligations. His discoveries in the theory of motion, in the laws of the descent of heavy bodies, and in the motion of projectiles, laid the foundation of all the great improvements which have since been made by the application of Mathematics to Natural Philosophy. If to this we add the invention of the telescope, the discoveries made by that instrument, the confirmations of the Copernican system which these discoveries afforded, and, lastly, the wit and argument with which he combated and exposed the prejudice and presumption of the schools, we must admit that the history of human knowledge contains few greater names than that of Galileo. On comparing him with Bacon, however, I have no hesitation in saying, that the latter has given indications of a genius of a still higher order. In this I know that I differ from a historian who was himself a philosopher, and whose suffrage, of consequence, is here of more than ordinary weight.

"The great glory of literature," says Hume, "in this island, during the reign of James, was Lord Bacon. If we consider the variety of talents displayed by this man, as a public speaker, a man of business, a wit, a courtier, a companion, an author, a philosopher, he is justly entitled to great admiration. If we consider him merely as an author and a philosopher, the light in which we view him at present, though very estimable, he was yet inferior to his contemporary Galileo, perhaps even to Kepler. Bacon pointed out, at a distance, the road to philosophy; Galileo both pointed it out to others, and made himself considerable advances in it. The Englishman was ignorant of geometry; the Florentine revived that science, excelled in it, and was the first who applied it, together with experiment, to natural philosophy. The former rejected, with the most positive disdain, the system of Copernicus; the latter fortified it with new proofs, derived both from reason and the senses. Bacon's style is stiff and rigid; his wit, though often brilliant, is also often unnatural and far-fetched. Galileo is a lively and agreeable, though somewhat a prolix writer."[1]

Though it cannot be denied that there is considerable truth in these remarks, yet it seems to me that the comparison is not made with the justness and discrimination which might have been expected from Hume, who appears studiously to have contrasted what is most excellent in Galileo with what is most defective in Bacon. It is true that Galileo showed the way in the application of mathematics and of geometry to physical investigation, and that the immediate utility of his performance was greater than that of Bacon's, as it impressed more movement on the age in which he lived, example being always so much more powerful than precept. Bacon, indeed, wrote for an age more enlightened than his own, and it was long before the full merit of his work was understood. But though Galileo was a geometer, and Bacon unacquainted with the mathematics,—though Galileo added new proofs to the system of the earth's motion, which Bacon rejected altogether,—yet is it certain, I think, that the former has more fellows or equals in the world of science than the latter, and that his excellence, though so high, is less unrivalled. The range which Bacon's speculations embraced was altogether immense. He cast a penetrating eye on the whole of science, from its feeblest and most infantine state, to that strength and perfection from which it was then so remote, and which it is perhaps destined to approach to continually, but never to attain. More substitutes might be found for Galileo than for Bacon. More than one could be mentioned, who, in the place of the former, would probably have done what he did; but the history of human knowledge points out nobody of whom it can be said, that, placed in the situation of Bacon, he would have done what Bacon did;—no man whose prophetic genius would have enabled him to delineate a system of science which had not yet begun to exist—who could have derived the knowledge of what *ought to be* from what *was not*, and who could have become so rich in wisdom, though he received from his predecessors no inheritance but their errors. I am inclined, therefore, to agree with D'Alembert, "that when one considers the sound and enlarged views of this great man, the multitude of the objects to which his mind was turned, and the boldness of his style, which unites the most sublime images with the most rigorous precision, one is disposed to regard him as the greatest, the most universal, and the most eloquent of philosophers."[1]

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[1] *History of England*, vol. VI. Appendix.

3. REMARKS, &c.

It will hardly be doubted by any one who attentively considers the method explained in the *Novum Organum*, which we have now attempted to sketch, that it contains a most comprehensive and rigorous plan of inductive investigation. A question, however, may occur, How far has this method been really carried into practice by those who have made the great discoveries in Natural Philosophy, and who have raised physical science to its present height in the scale of human knowledge? Is the whole method necessary, or have not circumstances occurred, which have rendered experimental investigation easier in practice than it appears to be in theory? To answer these questions completely, would require more discussion than is consistent with the limits of this Dissertation: I shall, therefore, attempt no more than to point out the principles on which such an answer may be founded.

In a very extensive department of physical science, it cannot be doubted that investigation has been carried on, not perhaps more easily, but with a less frequent appeal to experience, than the rules of the *Novum Organum* would seem to require. In all the physical inquiries where mathematical reasoning has been employed, after a few principles have been established by experience, a vast multitude of truths, equally certain with the principles themselves, have been deduced from them by the mere application of geometry and algebra.

In mechanics, for example, after the laws of motion were discovered, which was done by experiment, the rest of the science, to a great extent, was carried on by reasoning from those laws, in the same manner that the geometer makes his discoveries by reasoning on the definitions, by help of a few axioms, or self-evident propositions. The only difference is, that, in the one case, the definitions and axioms are supplied solely from the mind itself, while, in the other, all the definitions and axioms which are not those of pure geometry, are furnished by experience.[2]

Bacon certainly was not fully aware of the advantages that were thus to accrue to the physical sciences. He was not ignorant, that the introduction of mathematical reasoning into those sciences is not only possible, but that, under certain conditions, it may be attended with the greatest advantage. He knew also in what manner this application had been abused by the Platonists, who had attempted, by means of geometry, to establish the first principles of Physics, or had used them, *in axiomatis constituendis*, which is exactly the province belonging exclusively to experience. At the same time, he pointed out, with great precision, the place which the Mathematics may legitimately occupy, as serving to measure and compare the objects of physical inquiry. He did not, however, perceive beforehand, nor was it possible that he should, the vast extent to which the application of that science was capable of being carried. In the book *De Augmentis*, he has made many excellent remarks on this subject, full of the sagacity which penetrated so far into futurity, but, nevertheless, could only perceive a small part of the scene which the genius of Newton was afterwards to unfold.

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[1] Discours Préliminaire de l'Encyclopédie.

[2] The part of Mechanics which involves only statical considerations, or the equilibrium of forces, is capable of being treated by *reasoning a priori* entirely, without any appeal to experience. This will appear, when the subject of Mechanics is more particularly treated of.

Hence, the route which leads to many of the richest and most fertile fields of science, is not precisely that which Bacon pointed out; it is safer and easier; so that the voyager finds he can trust to his chart and compass alone, without constantly looking out, or having the sounding-line perpetually in his hand.

Another remark I must make on Bacon's method is, that it does not give sufficient importance to the *instantiæ radii*, or those which furnish us with accurate measures of physical quantities. The experiments of this class are introduced as only subservient to practice; they are, however, of infinite value in the theoretical part of induction, or for ascertaining the causes and essences of the things inquired into. We have an instance of this in the discovery of that important truth in physical astronomy, that the moon is retained in her orbit by the force of gravity, or the same which, at the earth's surface, makes a stone fall to the ground. This proposition, however it might have been suspected to be true, could never have been demonstrated but by such observations and experiments as assigned accurate geometrical measures to the quantities compared. The semidiameter of the earth; the velocity of falling bodies at the earth's surface; the distance of the moon, and her velocity in her orbit;—all these four elements must have been determined with great precision, and afterwards compared together by certain theorems deduced from the laws of motion, before the relation between the force which retains the moon in her orbit, and that which draws a stone to the ground, could possibly be discovered. The discovery also, when made, carried with it the evidence of demonstration; so that here, as in many other cases, the *instantiæ radii* are of the utmost importance in the theoretical part of Physics.

Another thing to be observed is, that, in many cases, the result of a number of particular facts, or the collective instance arising from them, can only be found out by geometry, which, therefore, becomes a necessary instrument in completing the work of induction. An example, which the science of optics furnishes, will make this clearer than any general description. When light passes from one transparent medium to another, it is refracted, that is, it ceases to go on in a straight line, and the angle which the incident ray makes with the superficies which bounds the two *media*, determines that which the refracted ray makes with the same superficies. Now, if we would learn any thing about the relation which these angles bear to one another, we must have recourse to experiment; and all that experiment can do is, for any particular angle of incidence, to determine the corresponding angle of refraction. This may be done in innumerable cases; but, with respect to the general rule which, in every possible case, determines the one of those angles from the other, or expresses the constant and invariable relation which subsists between them,—with respect to it, experiment gives no direct information. The methods of geometry must therefore be called in to our assistance, which, when a constant though unknown relation subsists between two angles, or two variable quantities of any kind, and when an indefinite number of values of those quantities are given, furnishes infallible means of discovering that unknown relation, either accurately, or at least by approximation. In this way it has been found, that, when the two *media* remain the same, the cosines of the angles above mentioned have a constant ratio to one another. Thus it appears, that, after experiment has done its utmost, geometry must be applied before the business of induction can be completed. This can only happen when the experiments afford accurate measures of the quantities concerned, like the *instantiæ radii, curriculi*, &c.; and this advantage of admitting generalization with so much certainty is one of their properties, of which it does not appear that even Bacon himself was aware.

Again, from the intimate connection which prevails among the principles of science, the success of one investigation must often contribute to the success of another, in such a degree as to make it unnecessary to employ the complete apparatus of induction from the beginning. When certain leading principles have been once established, they serve, in new investigations, to narrow the limits within which the thing sought for is contained, and enable the inquirer to arrive more speedily at the truth.

Thus, suppose that, after the nature of the reflection and refraction of light, and particularly of the colours produced by the latter, had been discovered by experiment, the cause of the rainbow were to be inquired into. It would, after a little consideration, appear probable, that the phenomenon to be explained depends on the reflection and refraction of light by the rain falling from a cloud opposite to the sun. Now, since the nature of reflection and refraction are supposed known, we have the principles previously ascertained which are likely to assist in the explanation of the rainbow. We have no occasion, therefore, to enter on the inquiry, as if the powers to be investigated were wholly unknown. It is the combination of them only which is unknown, and our business is to seek so to combine them, that the result may correspond with the appearances. This last is precisely what Newton accomplished, when, by deducing from the known laws of refraction and reflection the breadth of the coloured arch, the diameter of the circle of which it is a part, and the relation of the latter to the place of the spectator and of the sun, he found all these to come out from his calculus, just as they are observed in nature. Thus he proved the truth of his solution by the most clear and irresistible evidence.

The strict method of Bacon is therefore only necessary where the thing to be explained is new, and where we have no knowledge, or next to none, of the powers employed. This is but rarely the case, at least in some of the branches of Physics; and, therefore, it occurs most commonly in actual investigation, that the inquirer finds himself limited, almost from the first outset, to two or three hypotheses, all other suppositions involving inconsistencies which cannot for a moment be admitted. His business, therefore, is to compare the results of these hypotheses, and to consider what consequences may in any case arise from the one that would not arise from the other. If any such difference can be found, and if the matter is a subject of experiment, we have then an *instantia crucis* which must decide the question.

Thus, the *instantia crucis* comes in real practice to be the experiment most frequently appealed to, and that from which the most valuable information is derived.

In executing the method here referred to, the application of much reasoning, and frequently of much mathematical reasoning, is necessary, before any appeal to the experiment can be made, in order to deduce from each of the hypotheses an exact estimate of the consequences to which it leads. Suppose, for instance, that the law by which the magnetic virtue decreases in its intensity, as we recede from its poles, were to be inquired into. It is obvious that the number of hypotheses is here indefinite; and that we have hardly any choice but to begin with the simplest, or with that which is most analogous to the law of other forces propagated from a centre. Whatever law we assume, we must enter into a good deal of geometric reasoning, before a conclusion can be obtained, capable of being brought to the test of experience. The force itself, like all other forces, is not directly perceived, and its effects are not the result of its mere intensity, but of that intensity combined with the figure and magnitude of the body on which it acts; and, therefore, the calculus must be employed to express the measure of the effect, in terms of the intensity and the distance only. This being done, the hypothesis which gives results most nearly corresponding to the facts observed, when the magnet acts on the same body, at different distances, must be taken as the nearest approximation to the truth. We have here an instance of the use of hypothesis in inductive investigation, and, indeed, of the only legitimate use to which it can ever be applied.

It also appears that Bacon placed the ultimate object of philosophy too high, and too much out of the reach of man, even when his exertions are most skilfully conducted. He seems to have thought, that, by giving a proper direction to our researches, and carrying them on according to the inductive method, we should arrive at the knowledge of the essences of the powers and qualities residing in bodies; that we should, for instance, become acquainted with the essence of heat, of cold, of colour, of transparency. The fact however is, that, in as far as science has yet advanced, no one essence has been discovered, either as to matter in general, or as to any of its more extensive modifications. We are yet in doubt, whether heat is a peculiar motion of the minute parts of bodies, as Bacon himself conceived it to be; or something emitted or radiated from their surfaces; or lastly, the vibrations of an elastic medium, by which they are penetrated and surrounded. Yet whatever be the form or essence of heat, we have discovered a great number of its properties and its laws; and have done so, by pursuing with more or less accuracy the method of induction. We have also this consolation for the imperfection of our theoretical knowledge, that, in as much as art is concerned, or the possession of power over heat, we have perhaps all the advantages that could be obtained from a complete knowledge of its essence.

An equal degree of mystery hangs over the other properties and modifications of body; light, electricity, magnetism, elasticity, gravity, are all in the same circumstances; and the only advance that philosophy has made toward the discovery of the essences of these qualities or substances is, by exploding some theories, rather than by establishing any,—so true is Bacon's maxim, that the first steps in philosophy necessarily consist in negative propositions. Besides this, in all the above instances the laws of action have been ascertained; the phenomena have been reduced to a few general facts, and in some cases, as in that of gravity, to one only; and for aught that yet appears, this is the highest point which our science is destined to reach.

In consequence of supposing a greater perfection in knowledge than is ever likely to be attained, Bacon appears, in some respects, to have misapprehended the way in which it is ultimately to become applicable to art. He conceives that, if the *form* of any quality were known, we should be able, by inducing that form on any body, to communicate to it the said quality. It is not probable, however, that this would often lead to a more easy and simple process than that which art has already invented. In the case of colour, for example, though ignorant of its *form*, or of the construction of surface which enables bodies to reflect only light of a particular species, yet we know how to communicate that power from one body to another. Nor is it likely, though this structure were known with ever so great precision, that we should be able to impart it to bodies by any means so simple and easy, as by the common process of immersing them in a liquid of a given colour.

In some instances, however, the theories of Chemistry have led to improvements of art very conformable to the anticipations of the *Novum Organum*. A remarkable instance of this occurs in the process for bleaching, invented by Berthollet. It had been for some time known, that the combination of the chemical principle of oxygen with the colouring matter in bodies, destroyed or discharged the colour; and that, in the common process of bleaching, it was chiefly by the union of the oxygen of the air with the colouring matter in the cloth that this effect was produced. The excellent chemist just named conceived, therefore, that if the oxygen could be presented to the cloth in a dense state, and, at the same time, feebly combined with any other body, it might unite itself to the colouring matter so readily, that the process of bleaching would by that means be greatly accelerated. His skill in Chemistry suggested to him a way in which this might easily be done, by immersing the cloth in a liquid containing much oxygen in a loose state, or one in which it was slightly combined with other substances; and the effect followed so exactly, that he was able to perform in a few hours what required weeks, and even months, according to the common process. This improvement, therefore, was a real gift from the sciences to the arts; and came nearly, though not altogether, up to the ideas of Bacon. I suspect not altogether, because the manner in which oxygen destroys the colour of bodies, or alters the structure of their surfaces, remains quite unknown.

It was natural, however, that Bacon, who studied these subjects theoretically, and saw nowhere any practical result in which he could confide, should listen to the inspirations of his own genius, and ascribe to philosophy a perfection which it may be destined never to attain. He knew, that from what it had not yet done, he could conclude nothing against what it might hereafter accomplish. But after his method has been followed, as it has now been, with greater or less accuracy, for more than two hundred years, circumstances are greatly changed, and the impediments which, during all that time, have not yielded in the least to any effort, are perhaps never likely to be removed. This may, however, be a rash inference; Bacon, after all, may be in the right; and we may be judging under the influence of the vulgar prejudice, which has convinced men in every age, that they had nearly reached the farthest verge of human knowledge. This must be left for the decision of posterity; and we should rejoice to think, that judgment will hereafter be given against the opinion which at this moment appears most probable.

SECTION III.

MECHANICS.

1. THEORY OF MOTION.

Before the end of the sixteenth century, mechanical science had never gone beyond the problems which treat of the equilibrium of bodies, and had been able to resolve these accurately, only in the cases which can be easily reduced to the lever. Guido Ubaldi, an Italian mathematician, was among the first who attempted to go farther than Archimedes and the ancients had done in such inquiries. In a treatise which bears the date of 1577, he reduced the pulley to the lever; but with respect to the inclined plane, he continued in the same error with Pappus Alexandrinus, supposing that a certain force must be applied to sustain a body, even on a plane which has no inclination.

Stevinus, an engineer of the Low Countries, is the first who can be said to have passed beyond the point at which the ancients had stopped, by determining accurately the force necessary to sustain a body on a plane inclined at any angle to the horizon. He resolved also a great number of other problems connected with the preceding, but, nevertheless, did not discover the general principle of the composition of forces, though he became acquainted with this particular case, immediately applicable to the inclined plane.

The remark, that a chain laid on an inclined plane, with a part of it hanging over at top, in a perpendicular line, will be *in equilibrio*, if the two ends of the chain reach down exactly to the same level, led him to the conclusion, that a body may be supported on such a plane by a force which draws in a direction parallel to it, and has to the weight of the body the same ratio that the height of the plane has to its length.

Though it was probably from experience that Stevinus derived the knowledge of this proposition, he attempted to prove the truth of it by reasoning *a priori*. He supposed the two extremities of the chain, when disposed as above, to be connected by a part similar to the rest, which, therefore, must hang down, and form an arch. If in this state, says he, the chain were to move at all, it would continue to move for ever, because its situation, on the whole, never changing, if it were determined to move at one instant, it must be so determined at every other instant. Now, such perpetual motion, he adds, is impossible; and therefore the chain, as here supposed, with the arch hanging below, does not move. But the force of the arch below draws down the ends of the chain equally, because the arch is divided in the middle or lowest point into two parts similar and equal. Take away these two equal forces, and the remaining forces will also be equal; that is, the tendency of the chain to descend along the inclined plane, and the opposite tendency of the part hanging perpendicularly down, are equal, or are *in equilibrio* with one another. Such is the reasoning of Stevinus, which, whether perfectly satisfactory or not, must be acknowledged to be extremely ingenious, and highly deserving of attention, as having furnished the first solution of a problem, by which the progress of mechanical science had been long arrested. The first appearance of his solution is said to have had the date of 1585; but his works, as we now see them, were collected after his death, by his countryman Albert Girard, and published at Leyden in 1634.[1] Some discoveries of Stevinus in hydrostatics will be hereafter mentioned.

The person who comes next in the history of mechanics made a great revolution in the physical sciences. Galileo was born at Pisa in the year 1564. He early applied himself to the study of Mathematics and Natural Philosophy; and it is from the period of his discoveries that we are to date the joint application of experimental and geometrical reasoning to explain the phenomena of nature.

As early as 1592 he published a treatise, *della Scienza Mechanica*, in which he has given the theory, not of the lever only, but of the inclined plane and the screw; and has also laid down this general proposition, that mechanical engines make a small force equivalent to a great one, by making the former move over a greater space in the same time than the latter, just in proportion as it is less. No contrivance can make a small weight put a great one in motion, but such a one as gives to the small weight a velocity which is as much greater than that of the large weight, as this last weight is greater than the first. These general propositions, and their influence on the action of machinery, Galileo proceeded to illustrate with that clearness, simplicity, and extent of view, in which he was quite unrivalled; and hence, I think, it is fair to consider him as the first person to whom the mechanical principle, since denominated that of the *virtual velocities*, had occurred in its full extent. The object of his consideration was the action of machines in motion, and not merely of machines *in equilibrio*, or at rest; and he showed, that if the effect of a force be estimated by the weight it can raise to a given height in a given time, this effect can never be increased by any mechanical contrivance whatsoever.

In the same treatise, he lays it down as a postulate, (*supposizione*) that the effect of one heavy body to turn another round a centre of motion, is proportional to the perpendicular drawn from that centre to the vertical passing through the body, or in general to the direction of the force. This proposition he states without a demonstration, and passes by means of it to the oblique lever, and thence to the inclined plane. To speak strictly, however, the demonstrations with respect to both these last are incomplete, the preceding proposition being assumed in them without proof. It is probable that he satisfied himself of the truth of it, on the principle, that the distances of forces from the centre of motion must always be measured by lines making the *same* angles with their directions, and that of such lines the simplest are the perpendiculars. His demonstration is regarded by La Grange as quite satisfactory.[2]

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[1] The edition of Albert Girard is entitled *Œuvres Mathématiques de Stevins*, in folio. See livre i. *De la Statique*, théoréme 11. Stevinus also wrote a treatise on Navigation, which was published in Flemish in 1586, and was afterwards honoured with a translation into Latin, by Grotius. The merit of Stevinus has been particularly noticed by La Grange. (*Mécanique Analytique*, tom. I. sect. 1. § 5.)

[2] *Mécanique Analytique*, tom. I. sect. 1. § 6.

Galileo extended the theory of motion still farther. He had begun, while pursuing his studies at the University of Pisa, to make experiments on the descent of falling bodies, and discovered the fact, that heavy and light bodies fall to the ground from the same height in the same time, or in times so nearly the same that the difference can only be ascribed to the resistance of the air. From observing the vibrations of the lamps in the cathedral, he also arrived at this very important conclusion in mechanics, that the great and the small vibrations of the same pendulum are performed in the same time, and that this time depends only on the length of the pendulum. The date of these observations goes back as far as the year 1583.

These experiments drew upon him the displeasure of his masters, who considered it as unbecoming of their pupil to seek for truth in the Book of Nature, rather than in the writings of Aristotle, when elucidated by their commentaries; and from that moment began the persecutions with which the prejudice, the jealousy, and bigotry of his contemporaries continued to harass or afflict this great man throughout his whole life.

That the acceleration of falling bodies is uniform, or, that they receive equal increments of velocity in equal times, he appears first to have assumed as the law which they follow, merely on account of its simplicity. Having once assumed this principle, he showed, by mathematical reasoning, that the spaces descended through must be as the squares of the times, and that the space fallen through in one second is just the half of that which the body would have described in the same time with the velocity last acquired.

The knowledge which he already had of the properties of the inclined plane enabled him very readily to perceive, that a body descending on such a plane must be uniformly accelerated, though more slowly than when it falls directly, and is accelerated by its whole weight. By means of the inclined plane, therefore, he was able to bring the whole theory of falling bodies to the test of experiment, and to prove the truth of his original assumption, the uniformity of their acceleration.

His next step was to determine the path of a heavy body, when obliquely projected. He showed this path to be a parabola; and here, for the first time, occurs the use of a principle which is the same with the composition of motion in its full extent. Galileo, however, gave no name to this principle; he did not enunciate it generally, nor did he give any demonstration of it, though he employed it in his reasonings. The inertia of body was assumed in the same manner; it was, indeed, involved in the uniform acceleration of falling bodies; for these bodies did not lose in one minute the motion acquired in the preceding, but, retaining it, went on continually receiving more.

The theory of the inclined plane had led to the knowledge of this proposition, that if a circle be placed vertically, the chords of different arches terminating in the lowest point of the circle, are all descended through in the same space of time. This seemed to explain why, in a circle, the great and the small vibrations are of equal duration. Here, however, Galileo was under a mistake, as the motions in the chord and in the arch are very dissimilar. The accelerating force in the chord remains the same from the beginning to the end, but in the arch it varies continually, and becomes, at the lowest point, equal to nothing. The times in the chords, and in the arches, are therefore different, so that here we have a point marking the greatest distance in this quarter, to which the mechanical discoveries of Galileo extended. The first person who investigated the exact time of a vibration in an arch of a circle was Huygens, a very profound mathematician.

To this list of mechanical discoveries, already so important and extensive, we must add, that Galileo was the first who maintained the existence of the *law of continuity*, and who made use of it as a principle in his reasonings on the phenomena of motion.[1]

The vibrations of the pendulum having suggested to Galileo the means of measuring time accurately, it appears certain that the idea of applying it to the clock had also occurred to him, and of using the chronometer so formed for finding the longitude, by means of observations made on the eclipses of the satellites of Jupiter. How far he had actually proceeded in an invention which required great practical knowledge, and which afterwards did so much credit to Huygens, appears to be uncertain, and not now easy to be ascertained. But, that the project had occurred to him, and that he had taken some steps towards realizing it, is sufficiently established.

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[1] *Opere di Galileo*, tom. IV. dial. i. p. 32, Florence edition, and in many other parts.

One forms, however, a very imperfect idea of this philosopher, from considering the discoveries and inventions, numerous and splendid as they are, of which he was the undisputed author. It is by following his reasonings, and by pursuing the train of his thoughts in his own elegant, though somewhat diffuse exposition of them, that we become acquainted with the fertility of his genius, with the sagacity, penetration, and comprehensiveness of his mind. The service which he rendered to real knowledge is to be estimated, not only from the truths which he discovered, but from the errors which he detected,—not merely from the sound principles which he established, but from the pernicious idols which he overthrew. His acuteness was strongly displayed in the address with which he exposed the errors of his adversaries, and refuted their opinions, by comparing one part of them with another, and proving their extreme inconsistency. Of all the writers who have lived in an age which was yet only emerging from ignorance and barbarism, Galileo has most entirely the tone of true philosophy, and is most free from any contamination of the times, in taste, sentiment, and opinion.

The discoveries of this great man concerning motion drew the attention of philosophers more readily, from the circumstance that the astronomical theories of Copernicus had directed their attention to the same subject. It had become evident, that the great point in dispute between his system and the Ptolemaic must be finally decided by an appeal to the nature of motion and its laws. The great argument to which the friends of the latter system naturally had recourse, was the impossibility, as it seemed to them to be, of the swift motion of the earth being able to exist, without the perception, nay, even without the destruction of its inhabitants. It was natural for the followers of Copernicus to reply, that it was not certain that these two things were incompatible; that there were many cases in which it appeared, that the motion common to a whole system of bodies did not affect the motion of those bodies relatively to one another; that the question must be more deeply inquired into; and that, without this, the evidence on opposite sides could not be fairly and accurately compared. Thus, it was at a very fortunate moment that Galileo made his discoveries in mechanics, as they were rendered more interesting by those which, at that very time, he himself was making in astronomy. The system of Copernicus had, in this manner, an influence on the theory of motion, and, of course, on all the parts of Natural Philosophy. The *inertia* of matter, or the tendency of body, when put in motion, to preserve the quantity and direction of that motion, after the cause which impressed it has ceased to act, is a principle which might still have been unknown, if it had not been forced upon us by the discovery of the motion of the earth.

The first addition which was made to the mechanical discoveries of Galileo was by Torricelli, in a treatise *De Motu Gravium naturaliter descendentium et projectorum.*[1] To this ingenious man we are indebted for the discovery of a remarkable property of the centre of gravity, and a general principle with respect to the equilibrium of bodies. It is this: If there be any number of heavy bodies connected together, and so circumstanced, that by their motion their centre of gravity can neither ascend nor descend, these bodies will remain at rest. This proposition often furnishes the means of resolving very difficult questions in mechanics.

Descartes, whose name is so great in philosophy and mathematics, has also a place in the history of mechanical discovery. With regard to the action of machines, he laid down the same principle which Galileo had established,—that an equal effort is necessary to give to a weight a certain velocity, as to give to double the weight the half of that velocity, and so on in proportion, the effect being always measured by the weight multiplied into the velocity which it receives. He could hardly be ignorant that this proposition had been already stated by Galileo, but he has made no mention of it. He indeed always affected a disrespect for the reasonings and opinions of the Italian philosopher, which has done him no credit in the eyes of posterity.

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[1] *Vitæ Italorum Illustrium*, vol. I. p. 347.

The theory of motion, however, has in some points been considerably indebted to Descartes. Though the reasonings of Galileo certainly involve the knowledge of the disposition which matter has to preserve its condition either of rest or of rectilineal and uniform motion, the first distinct enunciation of this law is found in the writings of the French philosopher. It is, however, there represented, not as mere inactivity, or indifference, but as a real force, which bodies exert in order to preserve their state of rest or of motion; and this inaccuracy affects some of the reasonings concerning their action on one another.

Descartes, however, argued very justly, that all motion being naturally rectilineal, when a body moves in a curve, this must arise from some constraint, or some force urging it in a direction different from that of the first impulse, and that if this cause were removed at any time, the motion would become rectilineal, and would be in the direction of a tangent, to the curve at the point where the deflecting force ceased to act.

Lastly, he taught that the quantity of motion in the universe remains always the same.

The reasoning by which he supported the first and second of these propositions is not very convincing; and though he might have appealed to experience for the truth of both, it was not in the spirit of his philosophy to take that method of demonstrating its principles. His argument was, that motion is a state of body, and that body or matter cannot change its own state. This was his demonstration of the first proposition, from which the second followed necessarily.

The evidence produced for the third, or the preservation of the same quantity of motion in the universe, is founded on the immutability of the Divine nature, and is an instance of the intolerable presumption which so often distinguished the reasonings of this philosopher. Though the immutability of the Divine nature will readily be admitted, it remains to be shown, that the continuance of the same quantity of motion in the universe is a consequence of it. This, indeed, cannot be shown; for that quantity, in the sense in which Descartes understood it, is so far from being preserved uniform, that it varies continually from one instant to another. It is nevertheless true, that the quantity of motion in the universe, when rightly estimated, is invariable, that is, when reduced to the direction of three axes at right angles to one another, and when opposite motions are supposed to have opposite signs. This is a truth now perfectly understood, and is a corollary to the equality of action and reaction, in consequence of which, whatever motion is communicated in one direction, is either lost in that direction, or generated in the opposite. This, however, is quite different from the proposition of Descartes, and if expressed in his language, would assert, not that the sum, but that the difference of the opposite motions in the universe remains constantly the same. When he proceeds, by help of the principle which he had thus mistaken, to determine the laws of the collision of bodies, his conclusions are almost all false, and have indeed such a want of consistency and analogy with one another as ought, in the eyes of a mathematician, to have appeared the most decisive indications of error. How this escaped the penetration of a man well acquainted with the harmony of geometrical truths, and the gradual transitions by which they always pass into one another, is not easily explained, and perhaps, of all his errors, is the least consistent with the powerful and systematic genius which he is so well known to have possessed.

Thus, the obligation which the theory of motion has to this philosopher, consists in his having pointed out the nature of centrifugal force, and ascribed that force to the true cause, the inertia of body, or its tendency to uniform and rectilineal motion.

The laws which actually regulate the collision of bodies remained unknown till some years later, when they were recommended by the Royal Society of London to the particular attention of its members. Three papers soon appeared, in which these laws were all correctly laid down, though no one of the authors had any knowledge of the conclusions obtained by the other two. The first of these was read to the Society, in November 1668, by Dr Wallis of Oxford; the next by Sir Christopher Wren in the month following; and the third by Huygens in January 1669. The equality of action and reaction, and the maxim, that the same force communicates to different bodies velocities which are inversely as their masses, are the principles on which these investigations are founded.

The ingenious and profound mathematician last mentioned is also the first who explained the true relation between the length of a pendulum and the time of its least vibrations, and gave a rule by which the time of the rectilineal descent, through a line equal in length to the pendulum, might from thence be deduced. He next applied the pendulum to regulate the motion of a clock, and gave an account of his construction, and the principles of it, in his *Horologium Oscillatorium*, about the year 1670, though the date of the invention goes as far back as 1656.[1] Lastly, he taught how to correct the imperfection of a pendulum, by making it vibrate between cycloidal cheeks, in consequence of which its vibrations, whether great or small, became, not approximately, but precisely of equal duration.

Robert Hooke, a very celebrated English mechanician, laid claim to the same application of the pendulum to the clock, and the same use of the cycloidal cheeks. There is, however, no dispute as to the priority of Huygens's claim, the invention of Hooke being as late as 1670. Of the cycloidal cheeks, he is not likely to have been even the second inventor. Experiment could hardly lead any one to this discovery, and he was not sufficiently skilled in the Mathematics to have found it out by mere reasoning. The fact is, that though very original and inventive, Hooke was jealous and illiberal in the extreme; he appropriated to himself the inventions of all the world, and accused all the world of appropriating his.

It has already been observed, that Galileo conceived the application of the pendulum to the clock earlier, by several years, than either of the periods just referred to. The invention did great honour to him and to his two rivals; but that which argues the most profound thinker, and the most skilful mathematician of the three, is the discovery of the relation between the length of the pendulum and the time of its vibration, and this discovery belongs exclusively to Huygens. The method which he followed in his investigation, availing himself of the properties of the cycloid, though it be circuitous, is ingenious, and highly instructive.

An invention, in which Hooke has certainly the priority to any one, is the application of a spiral spring to regulate the balance of a watch. It is well known of what practical utility this invention has been found, and how much it has contributed to the solution of the problem of finding the longitude at sea, to which not only he, but Galileo and Huygens, appear all to have had an eye.

In what respects the theory of motion, Huygens has still another strong claim to our notice. This arises from his solution of the problem of finding the centre of oscillation of a compound pendulum, or the length of the simple pendulum vibrating in the same time with it. Without the solution of this problem, the conclusions respecting the pendulum were inapplicable to the construction of clocks, in which the pendulums used are of necessity compound. The problem was by no means easy, and Huygens was obliged to introduce a principle which had not before been recognised, that if the compound pendulum, after descending to its lowest point, were to be separated into particles distinct and unconnected with one another, and each left at liberty to continue its own vibration, the common centre of gravity of all those detached weights would ascend to the same height to which it would have ascended had they continued to constitute one body. The above principle led him to the true solution; and his investigation, though less satisfactory than those which have been since given, does great credit to his ingenuity. This was the most difficult mechanical inquiry which preceded the invention of the differential or fluxionary calculus.

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[1] Montucla, tom. II. p. 418, 2d edit.

2. HYDROSTATICS.

While the theory of motion, as applied to solids, was thus extended, in what related to fluids it was making equal progress. The laws which determine the weight of bodies immersed in fluids, and also the position of bodies floating on them, had been discovered by Archimedes, and were further illustrated by Galileo. It had also been discovered by Stevinus, that the pressure of fluids is in proportion to their depth; and thus the two leading principles of hydrostatics were established. Hydraulics, or the motion of fluids, was a matter of more difficulty; and here the first step is to be ascribed to Torricelli, who, though younger than Galileo, was for some time his contemporary. He proved that water issues from a hole in the side or bottom of a vessel, with the velocity which a body would acquire by falling from the level of the surface to the level of the orifice. This proposition, now so well known as the basis of the whole doctrine of hydraulics, was first published by Torricelli at the end of his book *De Motu Gravium et Projectorum;* but it is not the greatest discovery which science owes to the friend and disciple of Galileo. The latter had failed in assigning the reason why water cannot be raised in pumps higher than thirty-three feet; but he had remarked, that if a pump is more than thirty-three feet in length, a vacuum will be left in it. Torricelli, reflecting on this, conceived, that if a heavier fluid than water were used, a vacuum might be produced, in a way far shorter and more compendious. He tried mercury, therefore, and made use of a glass tube about three feet long, open at one end, and close at the other, where it terminated in a globe. He filled this tube, shut it with his finger, and inverted it in a basin of mercury. The result is well known: he found that a column of mercury was suspended in the tube, an effect which he immediately ascribed to the pressure of the atmosphere. So disinterested was this philosopher, however, that he is said to have lamented that Galileo, when inquiring into the cause why water does not ascend in pumps above a certain height, had not discovered the true cause of the phenomenon. The generosity of Torricelli was perhaps rarer than his genius. There are more who might have discovered the suspension of mercury in the barometer, than who would have been willing to part with the honour of the discovery to a master or a friend.

This experiment opened the door to a multitude of new discoveries, and demolished a formidable idol, the horror of a vacuum, to which so much power had been long attributed, and before which even Galileo himself had condescended to bow.

The objections which were made to the explanation of the suspension of the mercury in the tube of the barometer, were overthrown by carrying that instrument to the top of Puy de Dôme, an experiment suggested by Pascal. The descent of the mercury showed, that the pressure which supported it was less there than at the bottom; and it was afterwards found, that the fall of the mercury corresponded exactly to the diminution of the length of the pressing column, so that it afforded a measure of that diminution, and, consequently, of the heights of mountains. The invention of the air-pump by Otto Guericke, burgomaster of Magdeburg, quickly followed that of the barometer by Torricelli, though it does not appear that the invention of the Italian philosopher was known to the German. In order to obtain a space entirely void of air, Otto Guericke filled a barrel with water, and having closed it exactly on all sides, began to draw out the water by a sucking-pump applied to the lower part of the vessel. He had proceeded but a very little way, when the air burst into the barrel with a loud noise, and its weight was proved by the failure of the experiment, as effectually as it could have been by its success. After some other trials, which also failed, he thought of employing a sphere of glass, when the experiment succeeded, and a vacuum was obtained. This was about the year 1654.

The elasticity of the air, as well as its weight, now became known; its necessity to combustion, and the absorption of a certain proportion of it, during that process; its necessity for conveying sound;—all these things were clearly demonstrated. The necessity of air to the respiration of animals required no proof from experiment; but the sudden extinction of life, by immersion in a vacuum, was a new illustration of the fact.

The first considerable improvements made on the air-pump are due to Mr Boyle. He substituted to the glass globe of Otto Guericke a receiver of a more commodious form, and constructed his pump so as to be worked with much more facility. His experiments were farther extended,—they placed the weight and elasticity of the air in a variety of new lights,—they made known the power of air to dissolve water, &c. Boyle had great skill in contriving, and great dexterity in performing experiments. He had, indeed, very early applied himself to the prosecution of experimental science, and was one of the members of the small but distinguished body who, during the civil wars, held private meetings for cultivating natural knowledge, on the plan of Bacon. They met first in London, as early as 1645, afterwards at Oxford, taking the name of the *Philosophic College.* Of them, when Charles the Second ascended the throne, was formed the Royal Society of London, incorporated by letters patent in 1662. No one was more useful than Boyle in communicating activity and vigour to the new institution. A real lover of knowledge, he was most zealous in the pursuit of it; and having thoroughly imbibed the spirit of Bacon, was an avowed enemy to the philosophy of Aristotle.

SECTION IV.

ASTRONOMY.

1. ANCIENT ASTRONOMY.

It has already been remarked, that the ancients made more considerable advances in astronomy than in almost any other of the physical sciences. They applied themselves diligently to observe the heavens, and employed mathematical reasoning to connect together the insulated facts, which are the only objects of direct observation. The astronomer discovers nothing by help of his instruments, but that, at a given instant, a certain luminous point has a particular position in the heavens. The application of mathematics, and particularly of spherical trigonometry, enables him to trace out the precise track of this luminous spot; to discover the rate of its motion, whether varied or uniform; and thus to resolve the first great problem which the science of astronomy involves, viz. to express the positions of the heavenly bodies, relatively to a given plane in functions of the time. The problem, thus generally enunciated, comprehends all that is usually called by the name of descriptive or mathematical astronomy.

The explanation of the celestial motions, which naturally occurred to those who began the study of the heavens, was, that the stars are so many luminous points fixed in the surface of a sphere, having the earth in its centre, and revolving on an axis passing through that centre in the space of twenty-four hours. When it was observed that all the stars did not partake of this diurnal motion in the same degree, but that some were carried slowly towards the east, and that their paths estimated in that direction, after certain intervals of time, returned into themselves, it was believed that they were fixed in the surfaces of spheres, which revolved westward more slowly than the sphere of the fixed stars. These spheres must be transparent, or made of some crystalline substance; and hence the name of the crystalline spheres, by which they are distinguished. This system, though it grew more complicated in proportion to the number and variety of the phenomena observed, was the system of Aristotle and Eudoxus, and, with a few exceptions, of all the philosophers of antiquity.

But when the business of observation came to be regularly pursued,—when Timocharis and Aristillus, and their successors in the Alexandrian school, began to study the phenomena of the heavens,—little was said of these orbs; and astronomers seemed only desirous of ascertaining the laws or the general facts concerning the planetary motions.

To do this, however, without the introduction of hypothesis, was certainly difficult, and probably was then impossible. The simplest and most natural hypothesis was, that the planets moved eastward in circles, and at a uniform rate. But when it was found that, instead of moving uniformly to the eastward, every one of them was subject to great irregularity, the motion eastward becoming at certain periods slower, and at length vanishing altogether, so that the planet became stationary, and afterwards acquiring a motion in the contrary direction, proceeded for a time toward the west, it was far from obvious how all these appearances could be reconciled with the idea of a uniform circular motion.

The solution of this difficulty is ascribed to Apollonius Pergæus, one of the greatest geometers of antiquity. He conceived, that in the circumference of a circle, having the earth for its centre, there moved the centre of another circle, in the circumference of which the planet actually revolved. The first of these circles was called the *deferent*, and the second the *epicycle*, and the motion in the circumference of each was supposed uniform. Lastly, it was conceived that the motion of the centre of the epicycle in the circumference of the deferent, and of the planet in that of the epicycle, were in opposite directions, the first being towards the east, and the second towards the west. In this way, the alterations from progressive to retrograde, with the intermediate stationary points, were readily explained; and Apollonius carried his investigation so far as to determine the ratio between the radius of the deferent and that of the epicycle, from knowing the stations and retrogradations of any particular planet.

An object, which was then considered as of great importance to astronomy, was thus accomplished, viz. the production of a variable motion, or one which was continually changing both its rate and its direction from two uniform circular motions, each of which preserved always the same quantity and the same direction.

It was not long before another application was made of the method of epicycles. Hipparchus, the greatest astronomer of antiquity, and one of the inventors in science most justly entitled to admiration, discovered the inequality of the sun's apparent motion round the earth. To explain or to express this irregularity, the same observer imagined an epicycle of a small radius with its centre moving uniformly in the circumference of a large circle, of which the earth was the centre, while the sun revolved in the circumference of the small circle with the same angular velocity as this last, but in a contrary direction.

As other irregularities in the motions of the moon and of the planets were observed, other epicycles were introduced; and Ptolemy, in his *Almagest*, enumerated all which then appeared necessary, and assigned to them such dimensions as enabled them to express the phenomena with accuracy. It is not to be denied that the system of the heavens became in this way extremely complicated; though, when fairly examined, it will appear to be a work of great ingenuity and research. The ancients, indeed, may be regarded as very fortunate in the contrivance of epicycles, because, by means of them, every inequality which can exist in the angular motion of a planet may be at least nearly represented. This I call fortunate, because, at the time when Apollonius introduced the epicycle, he had no idea of the extent to which his contrivance would go, as he could have none of the conclusions which the author of the *Mécanique Céleste* was to deduce from the principle of gravitation.

The same contrivance had another great advantage; it subjected the motions of the sun, the moon, and the planets, very readily to a geometrical construction, or an arithmetical calculation, neither of them difficult. By this means the predictions of astronomical phenomena, the calculation of tables, and the comparison of those tables with observation, became matters of great facility, on which facility, in a great measure, the progress of the science depended. It was on these circumstances, much more than on the simplicity with which it amused or deceived the imagination, that the popularity of this theory was founded,—the ascendant which it gained over the minds of astronomers, and the resistance which, in spite of facts and observations, it was so long able to make to the true system of the world.

It does not appear that the ancient astronomers ever considered the epicycles and deferents which they employed in their system as having a physical existence, or as serving to *explain* the causes of the celestial motions. They seem to have considered them merely as mathematical diagrams, serving to *express* or to represent those motions as geometrical expressions of certain general facts, which readily furnished the rules of astronomical calculation.

The language in which Ptolemy speaks of the epicycles is not a little curious, and very conformable to the notion, that he considered them as merely the means of expressing a general law. After laying down the hypothesis of certain epicycles, and their dimensions, it is usual with him to add, " these suppositions will *save* the phenomena." *Save* is the literal translation of the Greek word, which is always a part of the verb Σωζειν, or some of its compounds. Thus, in treating of certain phenomena in the moon's motion, he lays down two hypotheses, by either of which they may be expressed; and he concludes, "in this way the similitude of the ratios, and the proportionality of the times, will be *saved* (διασωζοιντο) on both suppositions."[1] It is plain, from these words, that the astronomer did not here consider himself as describing any thing which actually existed, but as explaining two artifices, by either of which, certain irregularities in the moon's motion may be represented, in consistence with the principle of uniform velocity. The hypothesis does not relate to the explanation, but merely to the expression of the fact; it is first assumed, and its merit is then judged of synthetically, by its power to *save*, to reconcile, or to represent appearances. At a time when the mathematical sciences extended little beyond the elements, and when problems which could not be resolved by circles and straight lines could hardly be resolved at all, such artifices as the preceding were of the greatest value. They were even more valuable than the truth itself would have been in such circumstances; and nothing is more certain than that the real elliptical orbits of the planets, and the uniform description of areas, would have been very unseasonable discoveries at the period we are now treating of. The hypotheses of epicycles and of centres of uniform motion were well accommodated to the state of science, and are instances of a false system which has materially contributed to the establishment of truth.

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[1] *Mathematica Syntaxis*, lib. iv. p. 223 of the Paris edition.——Milton, the extent and accuracy of whose erudition can never be too much admired, had probably in view this phraseology of Ptolemy, when he wrote the following lines:

> ....He his fabric of the Heavens
> Hath left to their disputes, perhaps to move
> His laughter at their quaint opinions wide
> Hereafter, when they come to model Heaven
> And calculate the stars, how they will wield
> The mighty frame, how build, unbuild, contrive
> To *save appearances*, how gird the sphere
> With centrick and eccentrick scribbled o'er,
> Cycle and epicycle, orb in orb.

The obsolete verb *to salve* is employed by Bacon, and many others of the old English writers, in the same sense with Σωζειν in the work of Ptolemy here referred to. " The schoolmen were like the astronomers, who, to *salve* phenomena, framed to their conceit eccentricks and epicycles; so they, to *salve* the practice of the church, had devised a great number of strange positions." (BACON.)

2. COPERNICUS AND TYCHO.

On the revival of learning in Europe, astronomy was the first of the sciences which was regenerated. Such, indeed, is the beauty and usefulness of this branch of knowledge, that, in the thickest darkness of the middle ages, the study of it was never entirely abandoned. In those times of ignorance, it also derived additional credit from the assistance which it seemed to give to an imaginary and illusive science. Astrology, which has exercised so durable and extensive a dominion over the human mind, is coëval with the first observations of astronomy. In the middle ages, remarkable for the mixture of a few fragments of knowledge and truth in a vast mass of ignorance and error, it was assiduously cultivated, and, in conjunction with alchemy and magic, shared the favour of the people, and the patronage of the great. During the thirteenth and fourteenth centuries, it was taught in the universities of Italy, and professors were appointed, at Padua and Bologna, to instruct their pupils in the influence of the stars. Everywhere through Europe the greatest respect was shown for this system of imposture; and they who saw the deceit most clearly, could not always avoid the disgrace of being the instruments of it. Astronomy, however, profited by the illusion, and was protected for the great assistance which it seemed to afford to a science more important than itself.

Of those who cultivated astronomy, many were infected by this weakness, though some were completely superior to it. Alphonso, the King of Castile, was among the latter. He flourished about the middle of the thirteenth century, and was remarkable for such freedom of thought, and such boldness of language, as it required his royal dignity to protect. He applied himself diligently to the study of astronomy; he perceived the inaccuracy of Ptolemy's tables, and endeavoured to correct their errors by new tables of his own. These, in the course of the next age, were found to have receded from the heavens, and it became more and more evident that astronomers had not yet discovered the secret of the celestial motions.

Two of the men who, in the fifteenth century, contributed the most to the advancement of astronomical science, Purbach and Regiomontanus, were distinguished also for their general knowledge of the Mathematics. Purbach was fixed at Vienna by the patronage of the Emperor Frederick the Third, and devoted himself to astronomical observation. He published a new edition of the *Almagest*, and, though he neither understood Greek nor Arabic, his knowledge of the subject enabled him to make it much more perfect than any of the former translations. He is said to have been the first who applied the plummet to astronomical instruments; but this must not be understood strictly, for some of Ptolemy's instruments, the parallactic for instance, were placed perpendicularly by the plumb-line.

Regiomontanus was the disciple of Purbach, and is still more celebrated than his master. He was a man of great learning and genius, most ardent for the advancement of knowledge, and particularly devoted to astronomy. To him we owe the introduction of decimal fractions, which completed our arithmetical notation, and formed the second of the three steps by which, in modern times, the science of numbers has been so greatly improved.

In the list of distinguished astronomers, the name of Copernicus comes next, and stands at the head of those men who, bursting the fetters of prejudice and authority, have established truth on the basis of experience and observation. He was born at Thorn in Prussia, in 1473; he studied at the University of Cracow, being intended at first for a physician, though he afterwards entered into the church. A decided taste for astronomy led him early to the study of the science in which he was destined to make such an entire revolution; and as soon as he found himself fixed and independent, he became a diligent and careful observer.

It would be in the highest degree interesting to know by what steps he was led to conceive the bold system which removes the earth from the centre of the world, and ascribes to it a twofold motion. It is probable that the complication of so many epicycles and deferents as were necessary, merely to express the laws of the planetary motions, had induced him to think of all the possible suppositions which could be employed for the same purpose, in order to discover which of them was the simplest.

It appears extraordinary, that so natural a thought should have occurred, at so late a period, for the first, or nearly for the first time. We are assured by Copernicus himself, that one of the first considerations which offered itself to his mind, was the effect produced by the motion of a spectator, in transferring that motion to the objects observed, but ascribing to it an opposite direction.[1] From this principle it immediately followed, that the rotation of the earth on an axis, from west to east, would produce the apparent motion of the heavens in the direction from east to west.

In considering some of the objections which might be made to the system of the earth's motion, Copernicus reasons with great soundness, though he is not aware of the full force of his own argument. Ptolemy had alleged, that if the earth were to revolve on its axis, the violence of the motion would be sufficient to tear it in pieces, and to dissipate the parts. This argument, it is evident, proceeds on a confused notion of a centrifugal force, the effect of which the Egyptian astronomer overrated, as much as he undervalued the firmness and solidity of the earth. Why, says Copernicus, was he not more alarmed for the safety of the heavens, if the diurnal revolution be ascribed to them, as their motion must be more rapid, in proportion as their magnitude is greater? The argument here suggested, now that we know how to measure centrifugal force, and to compare it with others, carries demonstrative evidence with it; because that force, if the diurnal revolution were really performed by the heavens, would be such as the forces which hold together the frame of the material world would be wholly unable to resist.

There are, however, in the reasonings of Copernicus, some unsound parts, which show, that the power of his genius was not able to dispel all the clouds which in that age hung over the human mind, and that the unfounded distinctions of the Aristotelian Physics sometimes afforded arguments equally fallacious to him and to his adversaries. One of his most remarkable physical mistakes was his misconception with respect to the parallelism of the earth's axis; to account for which, he thought it necessary to assume, in addition to the earth's rotation on an axis, and revolution round the sun, the existence of a third motion altogether distinct from either of the others. In this he was mistaken; the axis naturally retains its parallelism, and it would require the action of a force to make it do otherwise. This, as Kepler afterwards remarked, is a consequence of the *inertia* of matter; and, for that reason, he very justly accused Copernicus of not being fully acquainted with his own riches.

The first edition of the *Astronomia Instaurata*, the publication of which was solicited by Cardinal Schoenberg, and the book itself dedicated to the Pope, appeared in 1543, a few days before the death of the author. Throughout the whole book, the new doctrine was advanced with great caution, as if from a presentiment of the opposition and injustice which it was one day to experience. At first, however, the system attracted little notice, and was rejected by the greater part even of astronomers. It lay fermenting in secret with other new discoveries for more than fifty years, till, by the exertions of Galileo, it was kindled into so bright a flame as to consume the philosophy of Aristotle, to alarm the hierarchy of Rome, and to threaten the existence of every opinion not founded on experience and observation.

After Copernicus, Tycho Brahé was the most distinguished astronomer of the sixteenth century. An eclipse of the sun which he witnessed in 1560, when he was yet a very young man, by the exactness with which it answered to the prediction, impressed him with the greatest reverence for a science which could see so far and so distinctly into the future; and from that moment he was seized with the strongest desire of becoming acquainted with it. Here, indeed, was called into action a propensity nearly allied both to the strength and the weakness of the mind of this extraordinary man; the same that attached him, on one hand, to the calculations of astronomy, and, on the other, to the predictions of judicial astrology.

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[1] *Astronomia Instaurata*, lib. i. cap. v.

In yielding himself up, however, to his love of astronomy, he found that he had several difficulties to overcome. He belonged to a class in society elevated, in the opinion of that age, above the pursuit of knowledge, and jealous of the privilege of remaining ignorant with impunity. Tycho was of a noble family in Denmark, so that it required all the enthusiasm and firmness inspired by the love of knowledge, to set him above the prejudices of hereditary rank, and the opposition of his relations. He succeeded, however, in these objects, and also in obtaining the patronage of the King of Denmark, by which he was enabled to erect an observatory, and form an establishment in the island of Huen, such as had never yet been dedicated to astronomy. The instruments were of far greater size, more skilfully contrived, and more nicely divided, than any that had yet been directed to the heavens. By means of them, Tycho could measure angles to ten seconds, which may be accounted sixty times the accuracy of the instruments of Ptolemy, or of any that had belonged to the school of Alexandria.

Among the improvements which he made in the art of astronomical observation, was that of verifying the instruments, or determining their errors by actual observation, instead of trusting, as had been hitherto done, to the supposed infallibility of the original construction.

One of the first objects to which the Danish astronomer applied himself, was the formation of a new catalogue of the fixed stars. That which was begun by Hipparchus, and continued by Ptolemy, did not give the places of the stars with an accuracy nearly equal to that which the new instruments were capable of reaching; and it was, besides, desirable to know whether the lapse of twelve centuries had produced any unforeseen changes in the heavens.

The great difficulty in the execution of this work arose from the want of a direct and easy method of ascertaining the distance of one heavenly body due east or west of another. The distance north or south, either from one another or from a fixed plane, that of the equator, was easily determined by the common method of meridian altitudes, the equator being a plane which, for any given place on the earth's surface, retains always the same position. But no plane extending from north to south, or passing through the poles, retains a fixed position with respect to an observer; and, therefore, the same way of measuring distances from such a plane cannot be applied. The natural substitute is the measure of time; the interval between the passage of two stars over the meridian, bearing the same proportion to twenty-four hours, that the arch which measures their distance perpendicular to the meridian, or their difference of right ascension, does to four right angles.

An accurate measure of time, therefore, would answer the purpose; but such a measure no more existed in the age of Tycho, than it had done in the days of Hipparchus or Ptolemy. These ancient astronomers determined the longitude of the fixed stars by referring their places to those of the moon, the longitude of which, for a given time, was known from the theory of her motions. Thus they were forced to depend on the most irregular of all the bodies in the heavens, for ascertaining the positions of the most fixed, those which ought to have been the basis of the former, and of so many other determinations. Tycho made use of the planet Venus instead of the moon; and his method, though more tedious, was more accurate than that of the Greek astronomers. His catalogue contained the places of 777 fixed stars.

The irregularities of the moon's motions were his next subjects of inquiry. The ancients had discovered the inequality of that planet depending on the eccentricity of the orbit, the same which is now called the equation of the centre.[1] Ptolemy had added the knowledge of another inequality in the moon's motion, to which the name of the evection has been given, amounting to an increase of the former equation at the quarters, and a diminution of it at the times of new and full moon. Tycho discovered another inequality, which is greatest at the octants, and depends on the difference between the longitude of the moon and that of the sun. A fourth irregularity to which the moon's motion is subject, depending wholly on the sun's place, was known to Tycho, but included among the sun's equations. Besides, these observations made him acquainted with the changes in the inclination of the plane of the moon's orbit; and, lastly, with the irregular motion of the nodes, which, instead of being always retrograde at the same rate, are subject to change that rate, and even to become progressive according to their situation in respect of the sun. These are the only inequalities of the moon's motion known before the theory of Gravitation, and, except the first two, are all the discoveries of Tycho.

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[1] The allowance made for any such equality, when the place of a planet is to be computed for a given time, is called an *equation* in the language of astronomy.

The atmospherical refraction, by which the heavenly bodies are made to appear more elevated above the horizon than they really are, was suspected before the time of this astronomer, but not known with certainty to exist. He first became acquainted with it by finding that the latitude of his observatory, as determined from observations at the solstices, and from observations of the greatest and least altitudes of the circumpolar stars, always differed about four minutes. The effect of refraction he supposed to be 34′ at the horizon, and to diminish from thence upward, till at 45° it ceased altogether. This last supposition is erroneous, but at 45° the refraction is less than 1′, and probably was not sensible in the altitudes measured with his instruments, or not distinguishable from the errors of observation. An instrument which he contrived on purpose to make the refraction distinctly visible, shows the scale on which his observatory was furnished. It was an equatorial circle of ten feet diameter, turning on an axis parallel to that of the earth. With the sights of this equatorial he followed the sun on the day of the summer solstice, and found, that as it descended towards the horizon, it rose above the plane of the instrument. At its setting, the sun was raised above the horizon by more than its own diameter.

The comet of 1570 was carefully observed by Tycho, and gave rise to a new theory of those bodies. He found the horizontal parallax to be 20′, so that the comet was nearly three times as far off as the moon. He considered comets, therefore, as bodies placed far beyond the reach of our atmosphere, and moving round the sun. This was a severe blow to the Physics of Aristotle, which regarded comets as meteors generated in the atmosphere. His observation of the new star in 1572 was no less hostile to the argument of the same philosopher, which maintained, that the heavens are a region in which there is neither generation nor corruption, and in which existence has neither a beginning nor an end.

Yet Tycho, with this knowledge of astronomy, and after having made observations more numerous and accurate than all the astronomers who went before him, continued to reject the system of Copernicus, and to deny the motion of the earth. He was, however, convinced that the earth is not the centre about which the planets revolve; for he had himself observed Mars, when in opposition, to be nearer to the earth than the earth was to the sun; so that, if the planets were ranged as in the Ptolemaic system, the orbit of Mars must have been within the orbit of the sun. He therefore imagined the system still known by his name, according to which the sun moves round the earth, and is at the same time the centre of the planetary motions. It cannot be denied, that the phenomena purely astronomical may be accounted for on this hypothesis, and that the objections to it are rather derived from physical and mechanical considerations than from the appearances themselves. It is simpler than the Ptolemaic system, and free from its inconsistencies; but it is more complex than the Copernican, and in no respect affords a better explanation of the phenomena. The true place of the Tychonic system is between the two former; an advance beyond the one, and a step short of the other; and such, if the progress of discovery were always perfectly regular, is the place which it would have occupied in the history of the science. If Tycho had lived before Copernicus, his system would have been a step in the advancement of knowledge; coming after him, it was a step backward.

It is not to his credit as a philosopher to have made this retrograde movement, yet he is not altogether without apology. The physical arguments in favour of the Copernican system, founded on the incongruity of supposing the greater body to move round the smaller, might not be supposed to have much weight, in an age when the equality of action and reaction was unknown, and when it was not clearly understood that the sun and the planets act at all on one another. The arguments which seem, in the judgment of Tycho, to have balanced the simplicity of the Copernican system, were founded on certain texts of Scripture, and on the difficulty of reconciling the motion of the earth with the sensations which we experience at its surface, or the phenomena which we observe, the same, in all respects, as if the earth were at rest. The experiments and reasonings of Galileo had not yet instructed men in the *inertia* of matter, or in the composition of motion; and the followers of Copernicus reasoned on principles which they held in common with their adversaries. A ball, it was said by the latter, dropt from the mast-head of a ship under sail, does not fall at the foot of the mast, but somewhat behind it; and in the same manner, a stone dropt from a high tower would not fall, on the supposition of the earth's motion, at the bottom of the tower, but to the west of it, the earth, during its fall, having gone eastward from under it. The followers of Copernicus were not yet provided with the true answer to this objection, viz. that the ball does actually fall at the bottom of the mast. It was admitted that it must fall behind it, because the ball was no part of the ship, and that the motion forward was not natural, either to the ship or to the ball. The stone, on the other hand, let fall from the top of the tower, was a part of the earth, and therefore the diurnal and annual revolutions which were natural to the earth were also natural to the stone; the stone would therefore retain the same motion with the tower, and strike the ground precisely at the bottom of it.

It must be confessed, that neither of these logicians had yet thoroughly awakened from the dreams of the Aristotelian metaphysics; but men were now in possession of the truth, which was finally to break the spell, and set the mind free from the fetters of prejudice and authority. Another charge, against which it is more difficult to defend Tycho, is his belief in the predictions of astrology. He even wrote a treatise in defence of this imaginary art, and regulated his conduct continually by its precepts. Credulity, so unworthy of a man deeply versed in real science, is certainly to be set down less to his own account than to that of the age in which he lived.

3. KEPLER AND GALILEO.

Kepler followed Tycho, and in his hands astronomy underwent a change only second to that which it had undergone in the hands of Copernicus. He was born in 1571. He early applied himself to study and observe the heavens, and was soon distinguished as an inventor. He began with taking a more accurate view of astronomical refraction than had yet been done, and he appears to have been the first who conceived that there must be a certain fixed law which determined the quantity of it, corresponding to every altitude, from the horizon to the zenith. The application of the principles of optics to astronomy, and the accurate distinction between the optical and real inequalities of the planets, are the work of the same astronomer. It was by the views thus presented that he was led to the method of constructing and calculating eclipses by means of projections, without taking into consideration the diurnal parallax. These are valuable improvements, but they were, however, obscured by the greatness of his future discoveries.

The planes of the orbits of the planets were naturally, in the Ptolemaic system, supposed to pass through the earth; and the reformation of Copernicus did not go so far as to change the notions on that subject which had generally been adopted. Kepler observed that the orbits of the planets are in planes passing through the sun, and that, of consequence, the lines of their nodes all intersect in the centre of that luminary. This discovery contributed essentially to those which followed.

The oppositions of the planets, or their places when they pass the meridian at midnight, offer the most favourable opportunities for observing them, both because they are at that time nearest to the earth, and because their places seen from thence are the same as if they were seen from the sun. The true time of the opposition had however been, till now, mistaken by astronomers, who held it to be at the moment when the apparent place of the planet was opposite to the mean place of the sun. It ought, however, to have been, when the apparent places of both were opposed to one another. This reformation was proposed by Kepler, and, though strenuously resisted by Tycho, was finally received.

Having undertaken to examine the orbit of Mars, in which the irregularities are most considerable, Kepler discovered, by comparing together seven oppositions of that planet, that its orbit is elliptical; that the sun is placed in one of the foci; and that there is no point round which the angular motion is uniform. In the pursuit of this inquiry he found that the same thing is true of the earth's orbit round the sun: hence by analogy it was reasonable to think, that all the planetary orbits are elliptical, having the sun in their common focus.

The industry and patience of Kepler, in this investigation, were not less remarkable than his ingenuity and invention. Logarithms were not yet known, so that arithmetical computation, when pushed to great accuracy, was carried on at a vast expense of time and labour. In the calculation of every opposition of Mars, the work filled ten folio pages, and Kepler repeated each calculation ten times, so that the whole work for each opposition extended to one hundred such pages: seven oppositions thus calculated produced a large folio volume.

In these calculations the introduction of hypotheses was unavoidable, and Kepler's candour in rejecting them, whenever they appeared erroneous, without any other regret than for the time which they had cost him, cannot be sufficiently admired. He began with hypothesis, and ended with rejecting every thing hypothetical. In this great astronomer we find genius, industry, and candour, all uniting together as instruments of investigation.

Though the angular motion of the planet was not found to be uniform, it was discovered that a very simple law connected that motion with the rectilineal distance from the sun, the former being everywhere inversely as the square of the latter; and hence it was easy to prove, that the area described by the line drawn from the planet to the sun increased at a uniform rate, and, therefore, that any two such areas were proportional to the times in which they were described. The picture presented of the heavens was thus, for the first time, cleared of every thing hypothetical.

The same astronomer was perhaps the first person who conceived that there must be always a law capable of being expressed by arithmetic or geometry, which connects such phenomena as have a physical dependence on one another. His conviction of this truth, and the delight which he appears to have experienced in the contemplation of such laws, led him to seek, with great eagerness, for the relation between the periodical times of the planets and their distances from the sun. He seems, indeed, to have looked towards this object with such earnestness, that, while it was not attained, he regarded all his other discoveries as incomplete. He at last found, infinitely to his satisfaction, that in any two planets the squares of the times of the revolution are as the cubes of their mean distances from the sun. This beautiful and simple law had a value beyond what Kepler could possibly conceive; yet a sort of scientific instinct instructed him in its great importance. He has marked the year and the day when it became known to him; it was on the 8th of May 1618; and perhaps philosophers will agree that there are few days in the scientific history of the world which deserve so well to be remembered.

These great discoveries, however, were not much attended to by the astronomers of that period, or by those who immediately followed. They were but little considered by Gassendi,—they were undervalued by Riccioli,—and were never mentioned by Descartes. It was an honour reserved for Newton to estimate them at their true value.

Indeed the discoveries of Kepler were at first so far from being duly appreciated, that they were objected to, not for being false, but for offering to astronomers, in the calculation of the place of a planet in its orbit, a problem too difficult to be resolved by elementary geometry. To cut the area of a semi-ellipsis in a given ratio by a line drawn through the focus, is the geometrical problem into which he showed that the above inquiry ultimately resolved. As if he had been answerable for the proceedings of nature, the difficulty of this question was considered as an argument against his theory, and he himself seems somewhat to have felt it as an objection, especially when he found that the best solution he could obtain was no more than an approximation. With all his power of invention, Kepler was a mathematician inferior to many of that period; and though he displayed great ability in the management of this difficult investigation, his solution fell very far short of the simplicity which it was afterwards found capable of attaining.

In addition to all this, he rendered another very important service to the science of astronomy and to the system of Copernicus. Copernicus, it has been already mentioned, had supposed that a force was necessary to enable the earth to preserve the parallelism of its axis during its revolution round the sun. He imagined, therefore, that a third motion belonged to the earth, and that, besides turning on its axis and revolving round the sun, it had another movement by which its axis was preserved always equally inclined to the ecliptic. Kepler was the first to observe that this third motion was quite superfluous, and that the parallelism of the earth's axis, in order to be preserved, required nothing but the absence of all force, as it necessarily proceeded from the inertia of matter, and its tendency to persevere in a state of uniform motion. Kepler had a clear idea of the inertia of body; he was the first who employed the term; and, considering all motion as naturally rectilineal, he concluded that when a body moves in a curve, it is drawn or forced out of the straight line by the action of some cause, not residing in itself. Thus he prepared the way for physical astronomy, and in these ideas he was earlier than Descartes.

The discoveries of Kepler were secrets extorted from nature by the most profound and laborious research. The astronomical discoveries of Galileo, more brilliant and imposing, were made at a far less expense of intellectual labour. By this it is not meant to say that Galileo did not possess, and did not exert, intellectual powers of the very highest order; but it was less in his astronomical discoveries that he had occasion to exert them, than in those which concerned the theory of motion. The telescope, turned to the heavens for the first time, in the hands of a man far inferior to the Italian philosopher, must have unfolded a series of wonders to astonish and delight the world.

It was in the year 1609 that the news of a discovery, made in Holland, reached Galileo, viz. that two glasses had been so combined as greatly to magnify the objects seen through them. More was not told, and more was not necessary to awaken a mind abundantly alive to all that interested the progress either of science or of art. Galileo applied himself to try various combinations of lenses, and he quickly fell on one which made objects appear greater than when seen by the naked eye, in the proportion of three to one. He soon improved on this construction, and found one which magnified thirty-two times, nearly as much as the kind of telescope he used is capable of. That telescope was formed of two lenses; the lens next the object convex, the other concave; the objects were presented upright, and magnified in their lineal dimensions in the proportion just assigned.

Having tried the effect of this combination on terrestrial objects, he next directed it to the moon. What the telescope discovers on the ever-varying face of that luminary, is now well known, and needs not to be described; but the sensations which the view must have communicated to the philosopher who first beheld it, may be conceived more easily than expressed. To the immediate impression which they made upon the sense, to the wonder they excited in all who saw them, was added the proof, which, on reflection, they afforded, of the close resemblance between the earth and the celestial bodies, whose divine nature had been so long and so erroneously contrasted with the ponderous and opaque substance of our globe. The earth and the planets were now proved to be bodies of the same kind, and views were entertained of the universe, more suitable to the simplicity and the magnificence of nature.

When the same philosopher directed his telescope to the fixed stars, if he was disappointed at finding their magnitudes not increased, he was astonished and delighted to find them multiplied in so great a degree, and such numbers brought into view, which were invisible to the naked eye. In Jupiter he perceived a large disk, approaching in size to the moon. Near it, as he saw it for the first time, were three luminous points ranged in a straight line, two of them on one side of the planet, and one on the other. This occasioned no surprise, for they might be small stars not visible to the naked eye, such as he had already discovered in great numbers. By observing them, however, night after night, he found these small stars to be four in number, and to be moons or satellites, accompanying Jupiter, and revolving round him, as the moon revolves round the earth.

The eclipses of these satellites, their conjunctions with the planet, their disappearance behind his disk, their periodical revolutions, and the very problem of distinguishing them from one another, offered, to an astronomer, a series of new and interesting observations.

In Saturn he saw one large disk, with two smaller ones very near it, and diametrically opposite, and always seen in the same places; but more powerful telescopes were required before these appearances could be interpreted.

The horned figure of Venus, and the gibbosity of Mars, added to the evidence of the Copernican system, and verified the conjectures of its author, who had ventured to say, that, if the sense of sight were sufficiently powerful, we should see Mercury and Venus exhibiting phases similar to those of the moon.

The spots of the sun derived an interest from their contrast with the luminous disk over which they seemed to pass. They were found to have such regular periods of return as could be derived only from the motion of the disk itself; and thus the sun's revolution on his axis, and the time of that revolution, were clearly ascertained.

This succession of noble discoveries, the most splendid, probably, which it ever fell to the lot of one individual to make, in a better age would have entitled its author to the admiration and gratitude of the whole scientific world, but was now viewed from several quarters with suspicion and jealousy. The ability and success with which Galileo had laboured to overturn the doctrines of Aristotle and the schoolmen, as well as to establish the motion of the earth and the immobility of the sun, had excited many enemies. There are always great numbers who, from habit, indolence, or fear, are the determined supporters of what is established, whether in practice or in opinion. To these the constitution of the universities of Europe, so entirely subjected to the church, had added a numerous and learned phalanx, interested to preserve the old systems, and to resist all innovations which could endanger their authority or their repose. The church itself was roused to action, by reflecting that it had staked the infallibility of its judgments on the truth of the very opinions which were now in danger of being overthrown. Thus was formed a vast combination of men, not very scrupulous about the means which they used to annoy their adversaries: the power was entirely in their hands, and there was nothing but truth and reason to be opposed to it.

The system of Copernicus, however, while it remained obscure, and known only to astronomers, created no alarm in the church. It had even been ushered into the world at the solicitation of a cardinal, and under the patronage of the Pope; but when it became more popular, when the ability and acuteness of Galileo were enlisted on its side, the consequences became alarming; and it was determined to silence by force an adversary who could not be put down by argument. His *Dialogues* contained a full exposition of the evidence of the earth's motion, and set forth the errors of the old, as well as the discoveries of the new philosophy, with great force of reasoning, and with the charms of the most lively eloquence. They are written, indeed, with such singular felicity, that one reads them at the present day, when the truths contained in them are known and admitted, with all the delight of novelty, and feels one's self carried back to the period when the telescope was first directed to the heavens, and when the earth's motion, with all its train of consequences, was proved for the first time. The author of such a work could not be forgiven. Galileo, accordingly, was twice brought before the Inquisition. The first time a council of seven cardinals pronounced a sentence which, for the sake of those disposed to believe that power can subdue truth, ought never to be forgotten: "That to maintain the sun to be immovable, and without local motion, in the centre of the world, is an absurd proposition, false in philosophy, heretical in religion, and contrary to the testimony of Scripture. That it is equally absurd and false in philosophy to assert that the earth is not immovable in the centre of the world, and, considered theologically, equally erroneous and heretical."

These seven theologians might think themselves officially entitled to decide on what was heretical or orthodox in faith; but, that they should determine what was true or false in philosophy, was an insolent invasion of a territory into which they had no right to enter, and is a proof how ready men are to suppose themselves wise, merely because they happen to be powerful. At this time a promise was extorted from Galileo, that he would not teach the doctrine of the earth's motion, either by speaking or by writing. To this promise he did not conform. His third dialogue, published, though not till long afterwards, contained such a full display of the beauty and simplicity of the new system, and such an exposure of the inconsistencies of Ptolemy and Tycho, as completed the triumph of Copernicus.

In the year 1633, Galileo, now seventy years old, being brought before the Inquisition, was forced solemnly to disavow his belief in the earth's motion; and condemned to perpetual imprisonment, though the sentence was afterwards mitigated, and he was allowed to return to Florence.[1] The Court of Rome was very careful to publish this second recantation all over Europe, thinking, no doubt, that it was administering a complete antidote to the belief of the Copernican system. The sentence, indeed, appears to have pressed very heavily on Galileo's mind, and he never afterwards either talked or wrote on the subject of astronomy. Such was the triumph of his enemies, on whom ample vengeance would have long ago been executed, if the indignation and contempt of posterity could reach the mansions of the dead.

Conduct like this, in men professing to be the ministers of religion and the guardians of truth, can give rise to none but the most painful reflections. That an aged philosopher should be forced, laying his hand on the sacred Scriptures, to disavow opinions which he could not cease to hold without ceasing to think, was as much a profanation of religion as a violation of truth and justice. Was it the act of hypocrites, who considered religion as a state engine, or of bigots, long trained in the art of believing without evidence, or even in opposition to it? These questions it were unnecessary to resolve; but one conclusion cannot be denied, that the indiscreet defenders of religion have often proved its worst enemies.

At length, however, by the improvements, the discoveries, and the reasonings, first of Kepler, and then of Galileo, the evidence of the Copernican system was fully developed, and nothing was wanting to its complete establishment but time sufficient to allow opinion to come gradually round, and to give men an opportunity of studying the arguments placed before them. Of the adherents of the old system, many had been too long habituated to it to change their views; but as they disappeared from the scene, they were replaced by young astronomers, not under the influence of the same prejudices, and eager to follow doctrines which seemed to offer so many new subjects of investigation. In the next generation the systems of Ptolemy and Tycho had no followers.

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[1] He was thrown into prison previously to his trial, and attempts were made to render him obnoxious to the people. From the text of a priest who preached against him, we may judge of the wit and the sense with which this persecution was conducted: *Viri Galilæi, quid statis in cœlum suspicientes?*

It was not astronomy alone which was benefited by this revolution, and the discussions to which it had given rise. A new light, as already remarked, was thrown on the physical world, and the curtain was drawn aside which had so long concealed the great experiment, by which nature herself manifests, at every instant, the inertia of body, and the composition of forces. To reconcile the real motion of the earth with its appearance of rest and with our feeling of its immobility, required such an examination of the nature of motion as discovered, if not its essence, at least its most general and fundamental properties. The whole science of rational mechanics profited, therefore, essentially by the discovery of the earth's motion.

A great barrier to philosophic improvement had arisen from the separation so early made, and so strenuously supported in the ancient systems, between terrestrial and celestial substances, and between the laws which regulate motion on the earth and in the heavens. This barrier was now entirely removed; the earth was elevated to the rank of a planet; the planets were reduced to the condition of earths; and by this mutual approach, the same rules of interpretation became applicable to the phenomena of both. Principles derived from experiments on the earth, became guides for the analysis of the heavens; and men were now in a situation to undertake investigations, which the most hardy adventurer in science could not before have dared to imagine. Philosophers had ascended to the knowledge of the affinities which pervade all nature, and which mark so strongly both the wisdom and unity of its author.

The light thus struck out darted its rays into regions the most remote from physical inquiry. When men saw opinions entirely disproved, which were sanctioned by all antiquity, and by the authority of the greatest names, they began to have different notions of the rules of evidence, of the principles of philosophic inquiry, and of the nature of the mind itself. It appeared that science was destined to be continually progressive; provided it was taken for an inviolable maxim, that all opinion must be ultimately amenable to experience and observation.

It was no slight addition to all these advantages, that, in consequence of the discussions from which Galileo had unhappily been so great a sufferer, the line was at length definitely drawn which was to separate the provinces of faith and philosophy from one another. It became a principle, recognised on all hands, that revelation, not being intended to inform men of those things which the unassisted powers of their own understanding would in time be able to discover, had, in speaking of such matters, employed the language and adopted the opinions of the times; and thus the magic circle, by which the priest had endeavoured to circumscribe the inquiries of the philosopher, entirely disappeared. The reformation in religion which was taking place about the same time, and giving such energy to the human mind, contributed to render this emancipation more complete, and to reduce the exorbitant pretensions of the Romish church. The prohibition against believing in the true system of the world either ceased altogether, or was reduced to an empty form, by which the affectation of infallibility still preserves the memory of its errors.[1]

4. DESCARTES, HUYGENS, &c.

DESCARTES flourished about this period, and has the merit of being the first who undertook to give an explanation of the celestial motions, or who formed the great and philosophic conception of reducing all the phenomena of the universe to the same law. The time was now arrived when, from the acknowledged assimilation of the planets to the earth, this might be undertaken with some reasonable prospect of success. No such attempt had hitherto been made, unless the crystalline spheres or homocentric orbs of the ancients are to be considered in that light. The conjectures of Kepler about a kind of animation, and of organic structure, which pervaded the planetary regions, were too vague and indefinite, and too little analogous to any thing known on the earth, to be entitled to the name of a theory. To Descartes, therefore, belongs the honour of being the first who ventured on the solution of the most arduous problem which the material world offers to the consideration of philosophy. For this solution he sought no other data than *matter* and *motion*, and with them alone proposed to explain the structure and constitution of the universe. The matter which he required, too, was of the simplest kind, possessing no properties but extension, impenetrability, and inertia. It was matter in the abstract, without any of its peculiar or distinguishing characters. To explain these characters was indeed a part of the task which he proposed to himself; and thus, by the simplicity of his assumptions, he added infinitely to the difficulty of the problem which he undertook to resolve.

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[1] The learned fathers who have, with so much ability, commented on the *Principia* of Newton, have prefixed to the third book this remarkable declaration: "Newtonus in hoc tertio libro telluris motæ hypothesin assumit. Auctoris propositiones aliter explicari non poterant, nisi eadem facta hypothesi. Hinc alienam coacti sumus gerere personam. *Ceterum latis a summis Pontificibus contra telluris motum Decretis nos obsequi profitemur.*" There is an archness in the last sentence, that looks as if the authors wanted to convey meanings that would differ according to the orthodoxy of the readers.

The matter thus constituted was supposed to fill all space, and its parts, both great and small, to be endued with motion in an infinite variety of directions. From the combination of these, the rectilineal motion of the parts became impossible; the atoms or particles of matter were continually diverted from the lines in which they had begun to move; so that circular motion and centrifugal force originated from their action on one another. Thus matter came to be formed into a multitude of vortices, differing in extent, in velocity, and in density; the more subtile parts constituting the real vortex, in which the denser bodies float, and by which they are pressed, though not equally, on all sides.

Thus the universe consists of a multitude of vortices, which limit and circumscribe one another. The earth and the planets are bodies carried round in the great vortex of the solar system; and by the pressure of the subtile matter, which circulates with great rapidity and great centrifugal force, the denser bodies, which have less rapidity and less centrifugal force, are forced down toward the sun, the centre of the vortex. In like manner, each planet is itself the centre of a smaller vortex, by the subtile matter of which the phenomena of gravity are produced, just as with us at the surface of the earth.

The gradation of smaller vortices may be continued in the same manner, to explain the cohesion of the grosser bodies, and their other sensible qualities. But I forbear to enter into the detail of a system which is now entirely exploded, and so inconsistent with the views of nature which have become familiar to every one, that such details can hardly be listened to with patience. Indeed the theory of vortices did not explain a single phenomenon in a satisfactory manner, nor is there a truth of any kind which has been brought to light by means of it. None of the peculiar properties of the planetary orbits were taken into the account; none of the laws of Kepler were considered; nor was any explanation given of those laws, more than of any other that might be imagined. The philosophy of Descartes could explain all things equally well, and might have been accommodated to the systems of Ptolemy or Tycho, just as well as to that of Copernicus. It forms, therefore, no link in the chain of physical discovery; it served the cause of truth only by exploding errors more pernicious than its own; by exhausting a source of deception, which might have misled other adventurers in science; and by leaving a striking proof how little advancement can be made in philosophy by pursuing any path but that of experiment and induction. Descartes was, nevertheless, a man of great genius, a deep thinker, of enlarged views, and entirely superior to prejudice. Yet, in as far as the explanation of astronomical phenomena is concerned, (and it was his main object) he did good only by showing in what quarter the attempt could not be made with success; he was the forlorn hope of the new philosophy, and must be sacrificed for the benefit of those who were to follow.

Gassendi, the contemporary and countryman of Descartes, possessed great learning, with a very clear and sound understanding. He was a good observer, and an enlightened advocate of the Copernican system. He explained, in a very satisfactory manner, the connection between the laws of motion and the motion of the earth, and made experiments to show, that a body carried along by another acquires a motion which remains after it has ceased to be so carried. Gassendi first observed the transit of a planet over the disk of the sun,—that of Mercury, in 1631. Kepler had predicted this transit, but did not live to enjoy a spectacle which afforded so satisfactory a proof of the truth of his system, and of the accuracy of his astronomical tables.

The first transit of Venus which was observed, happened a few years later, in 1639, when it was seen in England by Horrox and his friend Crabtree, and by them only. Horrox, who was a young man of great genius, had himself calculated the transit, and foretold the time very accurately, though the astronomical tables of that day gave different results; and those of Kepler, in which he confided the most, were, in this instance, considerably in error. Horrox has also the merit of being among the first who rightly appreciated the discoveries of the astronomer just named. He had devoted much time to astronomical observation, and, though he died very young, he left behind him some preparations for computing tables of the moon, on a principle which was new, and which Newton himself thought worthy of being adopted in his theory of the inequalities of that planet.

The first complete system of astronomy in which the elliptic orbits were introduced, was the *Astronomia Philolaica* of Bullialdus, (Boulliau) published in 1645. They were introduced, however, with such hypothetical additions, as show that the idea of a centre of uniform motion had not yet entirely disappeared. It is an idea, indeed, which gives considerable relief to the imagination, and it besides leads to methods of calculation more simple than the true theory, and Bullialdus may have flattered himself that they were sufficiently exact. He conceives the elliptic orbit as a section of an oblique cone, the axis of which passes through the superior focus of the ellipse, while the planet moves in its circumference in such a manner, that a plane passing through it and through the axis shall be carried round with a uniform angular velocity. It is plain that the cone and its axis are mere fictions, arbitrarily assumed, and not even possessing the advantage of simplicity. The author himself departs from this hypothesis, and calculates the places of a planet, on the supposition that it moves in the circumference of an epicycle, and the epicycle in the circumference of an eccentric deferent, both angular motions being uniform, that of the planet in the epicycle being retrograde, and double the other. The figure thus described may be shown to be an ellipse, but the line drawn from the planet to the focus does not cut off areas proportional to the time.

An hypothesis advanced by Ward, bishop of Salisbury, was simpler and more accurate than that of the French astronomer. According to it, the line drawn from a planet to the superior focus of its elliptic orbit, turns with a uniform angular velocity round that point. In orbits of small eccentricity, this is nearly true, and almost coincides in such cases with Kepler's principle of the uniform description of areas. Dr Ward, however, did not consider the matter in that light; he assumed his hypothesis as true, guided, it would seem, by nothing but the opinion, that a centre of uniform motion must somewhere exist, and pleased with the simplicity thus introduced into astronomical calculation. It is indeed remarkable, as Montucla has observed, how little the most enlightened astronomers of that time seem to have studied or understood the laws discovered by Kepler. Riccioli, of whom we are just about to speak, enumerates all the suppositions that had been laid down concerning the velocities of the planets, but makes no mention of their describing equal areas in equal times round the sun. Even Cassini, great as he was in astronomy, cannot be entirely exempted from this censure.

Riccioli, a good observer, and a learned and diligent compiler, has collected all that was known in astronomy about the middle of the seventeenth century, in a voluminous work, the *New Almagest*. Without much originality, he was a very useful author, having had, as the historian of astronomy remarks, the courage and the industry to read, to know, and to abridge every thing. He was, nevertheless, an enemy to the Copernican system, and has the discredit of having measured the evidence for and against that system, not by the weight, but by the number of the arguments. The pains which he took to prop the falling edifice of deferents and epicycles, added to his misapprehending and depreciating the discoveries of Kepler, subject him to the reproach of having neither the genius to discover truth, nor the good sense to distinguish it when discovered. He was, however, a priest and a jesuit; he had seen the fate of Galileo; and his errors may have arisen from want of courage, more than from want of discernment.

Of the phenomena which the telescope in the hands of Galileo had made known, the most paradoxical were those exhibited by Saturn; sometimes attended by two globes, one on each side, without any relative motion, but which would, at stated times, disappear for a while, and leave the planet single, like the other heavenly bodies. Nearly forty years had elapsed, without any further insight into these mysterious appearances, when Huygens began to examine the heavens with telescopes of his own construction, better and more powerful than any which had yet been employed. The two globes that had appeared insulated, were now seen connected by a circular and luminous belt, going quite round the planet. At last, it was found that all these appearances resulted from a broad ring surrounding Saturn, and seen obliquely from the earth. The gradual manner in which this truth unfolded itself is very interesting, and has been given with the detail that it deserves by Huygens, in his *Systema Saturnium*.

The attention which Huygens had paid to the ring of Saturn, led him to the discovery of a satellite of the same planet. His telescopes were not powerful enough to discover more of them than one; he believed, indeed, that there were no more, and that the number of the planets now discovered was complete. The reasoning by which he convinced himself, is a proof how slowly men are cured of their prejudices, even with the best talents and the best information. The planets, primary and secondary, thus made up twelve, the double of six, the first of the perfect numbers. In 1671, however, Cassini discovered another satellite, and afterwards three more, making five in all, which the more perfect telescopes of Dr Herschell have lately augmented to seven.

To the genius of Huygens astronomy is indebted for an addition to its apparatus, hardly less essential than the quadrant and the telescope. An accurate measure of time is of use even in the ordinary business of life, but to the astronomer is infinitely valuable. The dates of his observations, and an accurate estimate of the time elapsed between them, are necessary, in order to make them lead to any useful consequences. Besides this, the only way of measuring with accuracy those arches in the heavens, which extend from east to west, or which are parallel to the equator, depends on the earth's rotation; because such an arch bears the same proportion to the entire circumference of a circle, that the time of its passage under the meridian bears to an entire day. The reckoning of time thus furnishes the best measure of position, as determined by arches parallel to the equator, whether on the earth or in the heavens.

Though the pendulum afforded a measure of time, in itself of the greatest exactness, the means of continuing its motion, without disturbing the time of its vibrations, was yet required to be found; and this, by means of the clock, Huygens contrived most ingeniously to effect. Each vibration of the pendulum, by means of an arm at right angles to it, allows the tooth of a wheel to escape, the wheel being put in motion by a weight. The wheel is so contrived, that the force with which it acts is just sufficient to restore to the pendulum the motion which it had lost by the resistance of the air, and the friction at the centre of motion. Thus the motion of the clock is continued without any diminution of its uniformity, for any length of time.

The telescope had not yet served astronomy in all the capacities in which it could be useful. Huygens, of whose inventive genius the history of science has so much to record, applied it to the measurement of small angles, forming it into the instrument which has since been called a micrometer. By introducing into the focus of the telescope a round aperture of a given size, he contrived to measure the angle which that aperture subtended to the eye, by observing the time that a star placed near the equator required to traverse it. When the angle subtended by any other object in the telescope was to be measured, he introduced into the focus a thin piece of metal, just sufficient to cover the object in the focus. The proportion of the breadth of this plate to the diameter of the aperture formerly measured, gave the angle subtended by the image in the focus of the telescope. This contrivance is described in the *Systema Saturnium*, at the end.

The telescope has further contributed materially to the accuracy of astronomical observation, by its application to instruments used for measuring, not merely small angles, but angles of any magnitude whatever. The telescope here comes in place of the plain sights with which the index or *allidad* of an instrument used to be directed to an object, and this substitution has been accompanied with two advantages. The disk of a star is never so well defined to the naked eye as it is in the telescope. Besides, in using plain sights, the eye adapts itself to the farther off of the two, in order that its aperture may be distinctly seen. Whenever this adjustment is made, the object seen through the aperture necessarily appears indistinct to the eye, which is then adapted to a near object. This circumstance produces an uncertainty in all such observations, which, by the use of the telescope, is entirely removed.

But the greatest advantage arises from the magnifying power of the telescope, from which it follows, that what is a mere point to the naked eye, is an extended line which can be divided into a great number of parts when seen through the former. The best eye, when not aided by glasses, is not able to perceive an object which subtends an angle less than half a minute, or thirty seconds. When the index of a quadrant, therefore, is directed by the naked eye to any point in the heavens, we cannot be sure that it is nearer than half a minute on either side of that point. But when we direct the axis of a telescope, which magnifies thirty times, to the same object, we are sure that it is within the thirtieth part of half a minute, that is, within one second of the point aimed at. Thus the accuracy, *cæteris paribus*, is proportional to the magnifying power.

The application of the telescope, however, to astronomical instruments, was not introduced without opposition. Hevelius of Dantzic, the greatest observer who had been since Tycho Brahé, who had furnished his observatory with the best and largest instruments, and who was familiar with the use of the telescope, strenuously maintained the superiority of the plain sights. His principal argument was founded on this,—that, in plain sights, the line of collimation is determined in its position by two fixed points at a considerable distance from one another, viz. the centres of the two apertures of the sights, so that it remains invariable with respect to the index.

In the case of the telescope there was one fixed point, the intersection of the wires in the focus of the eye-glass; but Hevelius did not think that the other point, viz. the optical centre of the object-glass, was equally well defined. This doubt, however, might have been removed by a direct appeal to experiment, or to angles actually measured on the ground, first by an instrument, and then by trigonometrical operations. From thence it would soon have been discovered, that the centre of a lens is in fact a point defined more accurately than can be done by any mechanical construction.

This method of deciding the question was not resorted to. Hevelius and Hooke had a very serious controversy concerning it, in which the advantage remained with the latter. It should have been observed, that the French astronomer Picard was the first who employed instruments furnished with telescopic sights, about the year 1665. It appears, however, that Gascoigne, an English gentleman who fell at the battle of Marston-moor in 1644, had anticipated the French astronomer in this invention, but that it had remained entirely unknown. He had also anticipated the invention of the micrometer. The vast additional accuracy thus given to instruments formed a new era in the history of astronomical observations.

Though Galileo had discovered the satellites of Jupiter, their times of revolution, and even some of their inequalities, it yet remained to define their motions with precision, and to construct tables for calculating their places. This task was performed by the elder Cassini, who was invited from Italy, his native country, by Louis the Fourteenth, and settled in France in 1669. His tables of the satellites had been published at Bologna three years before, and he continued to improve them, by a series of observations made in the observatory at Paris, with great diligence and accuracy.

The theory of the motions of these small bodies is a research of great difficulty, and had been attempted by many astronomers before Cassini, with very little success. The planes of the orbits, their inclinations to the orbit of Jupiter, and the lines in which they intersected that orbit, were all to be determined, as well as the times of revolution, and the distances of each from its primary. Add to this, that it is only in a few points of their orbits that they can be observed with advantage. The best are at the times of immersion into the shadow of Jupiter, and emersion from it. The same excellent astronomer discovered four satellites of Saturn, in addition to that already observed by Huygens. He also discovered the rotation of Jupiter and of Mars upon their axes.

The constant attention bestowed on the eclipses of the satellites of Jupiter, made an inequality be remarked in the periods of their return, which seemed to depend on the position of the earth relatively to Jupiter and the sun, and not, as the inequalities of that sort might have been expected to do, on the place of Jupiter in his orbit. From the opposition of Jupiter to the sun, till the conjunction, it was found that the observed emersion of the satellites from the shadow fell more and more behind the computed; the differences amounting near the conjunction to about fourteen minutes. When, after the conjunction, the immersions were observed, an acceleration was remarked, just equal to the former retardation; so that, at the opposition, the eclipse happened fourteen minutes sooner than by the calculation.

The first person who offered an explanation of these facts was Olaus Roemer, a Danish astronomer. He observed that the increase of the retardation corresponded nearly to the increase of the earth's distance from Jupiter, and conversely, the acceleration to the diminution of that distance. Hence it occurred to him, that it was to the time which light requires to traverse those distances that the whole series of phenomena was to be ascribed. This explanation was so simple and satisfactory, that it was readily received.

Though Roemer was the first who communicated this explanation to the world, yet it seems certain that it had before occurred to Cassini, and that he was prevented from making it known by a consideration which does him great honour. The explanation which the motion of light afforded, seemed not to be consistent with two circumstances involved in the phenomenon. If such was the cause of the alternate acceleration and retardation above described, why was it observed only in the eclipses of the first satellite, and not in those of the other three? This difficulty appeared so great to Cassini, that he suppressed the explanation which he would otherwise have given.

The other difficulty occurred to Maraldi. Why did not an equation or allowance of the same kind arise from the position of Jupiter, with respect to his aphelion, for, all other things being the same, his distance from the earth must be greater, as he was nearer to that point of his orbit? Both these difficulties have since been completely removed. If the aforesaid inequality was not for some time observed in any satellite but the first, it was only because the motions of the first are the most regular, and were the soonest understood; but it now appears that the same equation belongs to all the satellites. The solution of Maraldi's difficulty is similar; for the quantity of what is called the equation of the light, is now known to be affected by Jupiter's place in his orbit.

Thus every thing conspires to prove the reality of the motion of light, so singular on account of the immensity of the velocity, and the smallness of the bodies to which it is communicated.

5. ESTABLISHMENT OF ACADEMIES, &c.

About the middle of the seventeenth century were formed those associations of scientific men, which, under the appellation of Academies or Philosophical Societies, have contributed so much to the advancement of knowledge in Europe. The *Academia del Cimento* of Florence, founded in 1651, carried in its name the impression of the new philosophy. It was in the country of Galileo where the first institution for the prosecution of experimental knowledge might be expected to arise; and the monuments which it has left behind it, will ever create regret for the shortness of its duration.

England soon after showed the same example. It has been already remarked, that, during the civil wars, a number of learned and scientific men sought, in the retirement of Oxford, an asylum from the troubles to which the country was then a prey. They had met as early as 1645; most of them were attached to the royal cause; and after the restoration of Charles the Second, they were incorporated by a royal charter in 1662.

The first idea of this institution seems to have been suggested by the writings of Bacon, who, in recommending the use of experiment, had severely censured the schools, colleges, and academies of his own time, as adverse to the advancement of knowledge;[1] and, in the *Nova Atlantis*, had given a most interesting sketch of the form of a society directed to scientific improvement. In Germany, the *Academia Naturæ Curiosorum* dates its commencement from 1652; and the historian of that institution ascribes the spirit which produced it to the writings of the philosopher just named. These examples, and a feeling that the union and co-operation of numbers were necessary to the progress of experimental philosophy, operated still more extensively. The Royal Academy of Sciences at Paris was founded in 1666, in the reign of Louis the Fourteenth, and during the administration of Colbert. The Institute of Bologna in Italy belongs nearly to the same period; but almost all the other philosophical associations, of which there are now so many, had their beginning in the eighteenth century.

Frequent communication of ideas, and a regular method of keeping up such communication, are evidently essential to works in which great labour and industry are to be employed, and to which much time must necessarily be devoted; when the philosopher must not always sit quietly in his cabinet, but must examine nature with his own eyes, and be present in the work-shop of the mechanic, or the laboratory of the chemist. These operations are facilitated by the institutions now referred to, which, therefore, are of more importance to the physical sciences than to the other branches of knowledge. They who cultivate the former are also fewer in number, and being, of course, farther separated, are less apt to meet together in the common intercourse of the world. The historian, the critic, the poet, finds everywhere men who can enter in some degree at least into his pursuits, who can appreciate his merit, and derive pleasure from his writings or his conversation. The ma-

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[1] "In moribus et institutis scholarum, academiarum, collegiorum, et similium conventuum, quæ doctorum hominum sedibus et eruditionis culturæ destinata sunt, omnia progressui scientiarum adversa inveniuntur. Lectiones enim et exercitia ita sunt disposita, ut aliud a consuetis haud facile cuiquam in mentem veniat cogitare aut contemplari. Si vero unus aut alter fortasse judicii libertate uti sustinuerit, is sibi soli hanc operam imponere possit; ab aliorum autem consortio nihil capiet utilitatis. Sin et hoc toleraverit, tamen in capessenda fortuna industriam hanc et magnanimitatem sibi non levi impedimento fore experietur. Studia enim hominum in ejusmodi locis in quorundam auctorum scripta, veluti in carceres, conclusa sunt; a quibus si quis dissentiat, continuo ut homo turbidus, et rerum novarum cupidus, corripitur....*In artibus autem et scientiis, tanquam in metalli fodinis, omnia novis operibus et ulterioribus progressibus circumstrepere debent.*" (*Novum Organum*, lib. i. cap. xc.)

It would be gratifying to be able to observe, that the universities of Europe had contributed to the renovation of science. The fact is otherwise; they were often the fastnesses from which prejudice and error were latest in being expelled. They joined in persecuting the reformers of science. It has been seen, that the masters of the University of Paris were angry with Galileo for the experiments on the descent of bodies. Even the University of Oxford brought on itself the indelible disgrace of persecuting, in Friar Bacon, the first man who appears to have had a distinct view of the means by which the knowledge of the laws of nature must be acquired thematician, the astronomer, the mechanician, sees few men who have much sympathy with his pursuits, or who do not look with indifference on the objects which he pursues. The world, to him, consists of a few individuals, by the censures or approbation of whom the public opinion must be finally determined; with them it is material that he should have more frequent intercourse than could be obtained by casual rencounter; and he feels that the society of men engaged in pursuits similar to his own is a necessary stimulus to his exertions. Add to this, that such societies become centres, in which information concerning facts is collected from all quarters. For all these reasons, the greatest benefit has resulted from the scientific institutions which, since the middle of the seventeenth century, have become so numerous in Europe.

The Royal Society of London is an association of men, who, without salaries or appointment from Government, defray, by private contribution, the expense of their meetings, and of their publications. This last is another important service which a society so constituted renders to science.

The demand of the public for memoirs in Mathematics and Natural Philosophy, many of them perhaps profound and difficult, is not sufficiently great to defray the expense of publication, if they come forward separately and unconnected with one another. In a collective state they are much more likely to draw the attention of the public; the form in which they appear is the most convenient both for the reader and the author; and if, after all, the sale of the work is unequal to the expense, the deficiency is made up from the funds of the society. An institution of this kind, therefore, is a patriotic and disinterested association of the lovers of science, who engage not only to employ themselves in discovery, but, by private contribution, to defray the expense of scientific publications.

The Academy of Sciences in Paris was not exactly an institution of the same kind. It consisted of three classes of members, one of which, the *Pensionnaires*, twenty in number, had salaries paid by Government, and were bound in their turn to furnish the meetings with scientific memoirs; and each of them also, at the beginning of every year, was expected to give an account of the work in which he was to be employed. This institution has been of incredible advantage to science. To detach a number of ingenious men from every thing but scientific pursuits; to deliver them alike from the embarrassments of poverty or the temptations of wealth; to give them a place and station in society the most respectable and independent, is to remove every impediment, and to add every stimulus to exertion. To this institution, accordingly, operating upon a people of great genius and indefatigable activity of mind, we are to ascribe that superiority in the mathematical sciences which, for the last seventy years, has been so conspicuous.

The establishment of astronomical observatories, as national or royal works, is connected in Europe with the institution of scientific or philosophical societies. The necessity of the former was, indeed, even more apparent than that of the latter. A science which has the heavenly bodies for its object, ought, as far as possible, to be exempted from the vicissitudes of the earth. As it gains strength but slowly, and requires ages to complete its discoveries, the plan of observation must not be limited by the life of the individual who pursues it, but must be followed out in the same place, year after year, to an unlimited extent. A perception of this truth, however indistinct, seems, from the earliest times, to have suggested the utility of observatories, to those sovereigns who patronized astronomy, whether they looked to that science for real or imaginary instruction. The circle of Osymandias is the subject of one of the most ancient traditions in science, and has preserved the name of a prince which otherwise would have been entirely unknown. A building, dedicated to astronomy, made a conspicuous part of the magnificent establishment of the school of Alexandria. During the middle ages, in the course of the migrations of science toward the east, sumptuous buildings, furnished with astronomical instruments, rose successively in the plains of Mesopotamia, and among the mountains of Tartary. An observatory in the gardens of the Caliph of Bagdad contained a quadrant of fifteen cubits[1] in radius, and a sextant of forty.[2] Instruments of a still larger size distinguished the observatory of Samarcand; and the accounts would seem incredible, if the ruins of Benares did not, at this moment, attest the reality of similar constructions.

On the revival of letters in Europe, establishments of the same kind were the first decisive indications of a taste for science. We have seen the magnificent observatory on which Tycho expended his private fortune, and employed the munificence of his patron, become a sad memorial (after the signal services which it had rendered to astronomy) of the instability of whatever depends on individual greatness. The observatories at Paris and London were secured from a similar fate, by being made national establishments, where a succession of astronomers were to devote themselves to the study of the heavens. The observatory at Paris was begun in 1667, and that at Greenwich in 1675. In the first of these, La Hire and Cassini, in the second, Flamsteed and Halley, are at the head of a series of successors who have done honour to their respective nations. If there be in Britain any establishment, in the success and conduct of which the nation has reason to boast, it is that of the Royal Observatory, which, in spite of a climate which so continually tries the patience, and so often disappoints the hopes of the astronomer, has furnished a greater number of observations to be completely relied on, than all the rest of Europe put together, and afforded the data for those tables in which the French mathematicians have expressed, with such accuracy, the past, the present, and the future condition of the heavens.

6. FIGURE AND MAGNITUDE OF THE EARTH.

The progress made during the seventeenth century, in ascertaining the magnitude and figure of the earth, is particularly connected with the establishments which we have just been considering. Concerning the figure of the earth, no accurate information was derived from antiquity, if we except that of the mathematical principle on which it was to be determined. The measurement of an arch of the meridian was attempted by Eratosthenes of Alexandria, in perfect conformity with that principle, but by means very inadequate to the importance and difficulty of the problem. By measuring the sun's distance from the zenith of Alexandria on the solstitial day, and by knowing, as he thought he did, that on the same day the sun was exactly in the zenith of Syene, he found the distance in the heavens between the parallels of those places to be 7° 12′, or a 50th part of the circumference of a great circle. Supposing, then, that Alexandria and Syene were in the same meridian, nothing more was required than to find the distance between them, which, when multiplied by 50, would give the circumference of the globe. The manner in which this was attempted by Eratosthenes, is quite characteristic of the infant state of the arts of experiment and observation. He took no trouble to ascertain whether Alexandria and Syene were due north and south of one another: the truth is, that the latter is considerably east of the former; so that, though their horizontal distance had been accurately known, a considerable reduction would have been necessary, on account of the distance of the one from the meridian of the other. It does not appear, however, that Eratosthenes was at any more pains to ascertain the distance than the bearing of the two places. He assumed the former just as it was commonly estimated; and, indeed, it appears that the distance was not measured till long afterwards, when it was done by the command of Nero.

It was in this way that the ancients made observations and experiments; the mathematical principles might be perfectly understood, but the method of obtaining accurate data for the application of those principles was not a subject of attention. The *power* of resolving the problem was the main object; and the actual solution was a matter of very inferior importance.

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[1] Twenty-two feet three inches.

[2] Sixty feet five inches.

The slowness with which the art of making accurate experiments and observations has been matured, and the great distance it has kept behind theory, is a remarkable fact in the history of the physical sciences. It has been remarked, that mathematicians had found out the area of the circle, and calculated its circumference to more than a hundred places of decimals, before artists had divided an arch into minutes of a degree; and that many excellent treatises had been written on the properties of curves, before a straight line had been drawn of any considerable length, or measured with any tolerable exactness, on the surface of the globe.[1]

The next measurement on record is that of the astronomers of Almamon, in the plains of Mesopotamia; and the manner of conducting the operation appears to have been far more accurate than that of the Greek philosophers; but, from a want of knowledge of the measures employed, it has conveyed no information to posterity.

The first arch of the meridian, measured in modern times with an accuracy any way corresponding to the difficulty of the problem, was by Snellius, a Dutch mathematician, who has given an account of it in a volume which he calls *Eratosthenes Batavus*, published in 1617. The arch was between Bergen-op-Zoom and Alkmaar; its amplitude was 1° 11′ 30″, and the distance was determined by a series of triangles, depending on a base line carefully measured. The length of the degree that resulted was 55,021 toises, which, as was afterwards found, is considerably too small. Certain errors were discovered, and when they were corrected, the degree came out 57,033 toises, which is not far from the truth. The corrections were made by Snellius himself, who measured his base over again, and also the angles of the triangles. He died, however, before he could publish the result. Muschenbroek, who calculated the whole anew from his papers, came to the conclusion just mentioned, which, of course, was not known till long after the time when the measure was executed. No advantage, accordingly, was derived to the world from this measurement till its value was lost in that of other measurements still more accurately conducted.

A computation which, for the time, deserves considerable praise, is that of Norwood, in 1635, who measured the distance between London and York, taking the bearings as he proceeded along the road, and reducing all to the direction of the meridian, and to the horizontal plane. The difference of latitude he found, by observation of the solstices, to be 2° 28′; and from that and his measured distance, he concluded the degree to be 367,176 feet English, or 57,800 toises. This has been found to be a near approximation; yet his method was not capable of great accuracy, nor did he always execute it in the best manner. "Sometimes," says he, "I measured, sometimes I *paced;* and I believe I am within a *scantling* of the truth."

Fernel, a French physician, measured with a wheel from Paris to Amiens, which are nearly in the same meridian, and he determined the degree from thence to be 56,746 French toises; a result which falls short of the truth, though not very considerably.

These investigations, it is plain, could not but leave considerable uncertainty with respect to the magnitude of the earth. The Academy of Sciences became interested in the question, and the measurement of an arch in the meridian was undertaken under its auspices, and executed by the Abbé Picard, already known for his skill in the operations of practical geometry. He followed a method similar to that of Snellius, according to which, the distance between Amiens and Malvoisine was found from a series of triangles, and a base of 5663½ toises. He determined the difference of latitude by means of a zenith sector of ten feet radius, and found it to be 1° 22′ 55″. The whole distance was 78,850 toises, whence the degree came out 57,060 toises. This was the first measurement of a degree of the meridian on which perfect reliance could be placed.

Hitherto no doubt had been entertained of the spherical figure of the earth, and, of consequence, of the equality of all the degrees of the meridian, so that if one was known, the whole circumference was determined. Men, with the precipitation which they so often manifest, of assuming, without sufficient evidence, the conclusion which appears most simple, were no sooner satisfied that the earth was round, than they supposed it to be truly spherical. An observation soon occurred, which gave reason to suspect, that much more must be done before its figure or its magnitude could be completely ascertained.

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[1] *Edinburgh Review*, vol. V. p. 391.

With a view of observing the sun's altitude in the vicinity of the equator, where the distance from the zenith being inconsiderable, the effects of refraction must be of small account, it was agreed, by the same academy, to send an astronomer, M. Richer, to make observations at the island of Cayenne, in South America.

Richer observed the solstitial altitude of the sun at that place in 1672, and found the distance of the tropics to be 46° 57′ 4″, and therefore the obliquity of the ecliptic 23° 28′ 32″; agreeing almost precisely with the determination of Cassini.

The most remarkable circumstance, however, which occurred in the course of this voyage, was, that the clock, though furnished with a pendulum of the same length which vibrated seconds at Paris, was found, at Cayenne, to lose two minutes and a half a-day nearly. This created great astonishment in France, especially after the accuracy of it was confirmed by the observations of Varin and Deshayes, who, some years afterwards, visited different places on the coasts of Africa and America, near the line, and found the necessity of shortening the pendulum, to make it vibrate seconds in those latitudes. The first explanation of this remarkable phenomenon was given by Newton, in the third book of his *Principia*, published in 1687, where it is deduced as a necessary consequence of the earth's rotation on its axis, and of the centrifugal force thence arising. That force changes both the direction and the intensity of gravity, giving to the earth an oblate spheroidal figure, more elevated at the equator than the poles, and making bodies fall, and pendulums vibrate, more slowly in low than in high latitudes.

This solution, however, did not, any more than the book in which it was contained, make its way very readily into France. The first explanation of the retardation of the pendulum, which was received there, was given by Huygens in 1690. Huygens deduced it also from the centrifugal force, arising from the earth's rotation, and the view which he took was simpler, though much less accurate than that of Newton. It had indeed the simplicity which often arises from neglecting one of the essential conditions of a problem; but it was nevertheless ingenious, and involved a very accurate knowledge of the nature of centrifugal force.—I am thus brought to touch on a subject which belongs properly to the second part of this Dissertation, for which the fuller discussion of it must of course be reserved.

SECTION V.

OPTICS.

1. OPTICAL KNOWLEDGE OF THE ANCIENTS.

On account of the rectilineal propagation of light, the phenomena of optics are easily expressed in the form of mathematical propositions, and seem, as it were, spontaneously to offer themselves to the study of geometers. Euclid, perceiving this affinity, began to apply the science which he had already cultivated with so much success, to explain the laws of vision, before a similar attempt had been made with respect to any other branch of terrestrial Physics, and at least fifty years before the researches of Archimedes had placed mechanics among the number of the mathematical sciences.

In the treatise ascribed to Euclid, there are, however, only two physical principles which have completely stood the test of subsequent improvement. The first of these is the proposition just referred to, that a point in any object is seen in the direction of a straight line drawn from the eye to that point; and the second is, that when a point in an object is seen by reflection from a polished surface, the lines drawn from the eye and from the object to the point whence the reflection is made, are equally inclined to the reflecting surface. These propositions are assumed as true: they were, no doubt, known before the time of Euclid; and it is supposed that the discovery of them was the work of the Platonic school. The first of them is the foundation of Optics proper, or the theory of vision by direct light; the second is the foundation of Catoptrics, or the theory of vision by reflected light. Dioptrics, or vision by refracted light, had not yet become an object of attention.

Two other principles which Euclid adopted as postulates in his demonstrations, have not met with the same entire confirmation from experiment, and are indeed true only in certain cases, and not universally, as he supposed. The first of these is, that we judge of the magnitude of an object altogether by the magnitude of the optical angle, or the angle which it subtends at the eye. It is true that this angle is an important element in that judgment; and Euclid, by discovering this, came into the possession of a valuable truth; but by a species of sophistry, very congenial to the human mind, he extended the principle too far, and supposed it to be the only circumstance which determines our judgment of visible magnitude. It is, indeed, the only measure which we are furnished with directly by the eye itself; but there are few cases in which we form our estimate without first appealing to the commentary afforded by the sensations of touch, or the corrections derived from our own motion.

Another principle, laid down by the same geometer, is in circumstances nearly similar to the preceding. According to it, the place of any point of an object seen by reflection is always the intersection of the reflected ray, with the perpendicular drawn from that point to the reflecting surface. The proof offered is obscure and defective; the proposition, however, is true, of plain speculums always, and of spherical as far as Euclid's investigations extended, that is, while the rays fall on the speculum with no great obliquity. His assumption, therefore, did not affect the truth of his conclusions, though it would have been a very unsafe guide in more general investigations. The book is in many other respects imperfect, the reasoning often unsound, and the whole hardly worthy of the great geometer whose name it bears. There is, however, no doubt that Euclid wrote on the subject of optics, and many have supposed that this treatise is a careless extract, or an unskilful abridgement of the original work.

Antiquity furnished another mathematical treatise on optics, that of the astronomer Ptolemy. This treatise, though known in the middle ages, and quoted by Roger Bacon, had disappeared, and was supposed to be entirely lost, till within these few years, when a manuscript on optics, professing to be the work of Ptolemy, and to be translated from the Arabic, was found in the King's Library at Paris. The most valuable part of this work is that which relates to refraction, from whence it appears that many experiments had been made on that subject, and the angles of incidence and refraction, for different transparent substances, observed with so much accuracy, that the same ratio, very nearly, of the sines of these angles, from air into water or into glass, is obtained from Ptolemy's numbers, which the repeated experiments of later times have shown to be true. The work, however, in the state in which it now appears, is very obscure, the reasoning often deficient in accuracy, and the mathematical part much less perfect than might have been expected. Modern writers, presuming partly on the reputation of Ptolemy, and partly guided by the authority of Roger Bacon, had ascribed to this treatise more merit than it appears to possess; and, of consequence, had allowed less to the Arabian author Alhazen, who comes next in the order of time, than of right belongs to him. Montucla, on the authority of Bacon, says, that Ptolemy ascribed the increase of the apparent magnitude of the heavenly bodies near the horizon, to the greater distance at which they are supposed to be, on account of the number of intervening objects across which they are seen. Ptolemy's explanation, however, as stated by Delambre,[1] from the manuscript just mentioned, is quite different from this, and amounts to no more than the vague and unsatisfactory remark, that an observer looks at the bodies near the zenith in a constrained posture, and in a situation to which the eye is not accustomed. The former explanation, therefore, given by Alhazen, but supposed to have been borrowed from Ptolemy, must now be returned to its right owner. It is the best explanation yet known.

These are the only mathematical treatises on optics of any consideration which the ancients have transmitted to us;[2] but many metaphysical speculations on light and vision are to be found in the writings of the philosophers. Aristotle defined light much as he had defined motion; *the act or energy of a transparent body, in as much as it is transparent.* The reason for calling light an act of a transparent body is, that, though a body may be transparent in power or capacity, it does not become actually transparent but by means of light. Light brings the transparency into action; it is, therefore, the act of a transparent body. In such miserable puerilities did the genius of this great man exhaust itself, owing to the unfortunate direction in which his researches were carried on.

In his further speculations concerning light, he denied it to be a substance; and his argument contains a singular mixture of the ingenious and the absurd. The time, he says, in which light spreads from one place to another is infinitely small, so that light has a velocity which is infinitely great. Now, bodies move with a velocity inversely as the quantities of matter which they contain; light, therefore, cannot contain any matter, that is, it cannot be material.[3] That the velocity of light was infinitely great, seemed to him to follow from this, that its progress, estimated either in the direction of north and south or of east and west, appeared to be instantaneous. In the opinion of the Platonists, and of the greater part of the ancients, vision was performed by means of certain rays which proceeded from the eye to the object, though they did not become the instruments of conveying sensations to the mind, but in consequence of the presence of light. In this theory, we can now see nothing but a rude and hasty attempt to assimilate the sense of sight to that of touch, without inquiring sufficiently into the particular characters of either.

Epicurus, and the philosophers of his school, as we learn from Lucretius, entertained more correct notions of vision, though they were still far from the truth. They conceived vision to be performed in consequence of certain *simulacra*, or images continually thrown off from the surfaces of bodies, and entering the eye. This was the substitute in their philosophy for rays of light, and had at least the merit of representing that which is the medium of vision, or which forms the communication between the eye and external objects, as something proceeding from the latter. The idea of *simulacra*, or *spectra*, flying off continually from the surfaces of bodies, and entering the eye, was perhaps as near an approach to the true theory of vision as could be made before the structure of the eye was understood.

In the arts connected with optics, the ancients had made some progress. They were sufficiently acquainted with the laws of reflection to construct mirrors both plane and spherical. They made them also conical; and it appears from Plutarch, that the fire of Vesta, when extinguished, was not permitted to be rekindled but by the rays of the sun, which were condensed by a conical speculum of copper. The mirrors with which Archimedes set fire to the Roman galleys have been subjects of much discussion, and the fact was long disbelieved, on the ground of being physically impossible. The experiments of Kircher and Buffon showed that this impossibility was entirely imaginary, and that the effect ascribed to the *specula* of the Greek geometer might be produced without much difficulty. There remains now no doubt of their reality. A passage from Aristophanes[1] gives reason to believe that, in his time, lenses of glass were used for burning, by collecting the rays of the sun; but in a matter that concerns the history of science, the authority of a comic poet and a satirist would not deserve much attention, if it were not confirmed by more sober testimony. Pliny, speaking of rock crystal,[2] says that a globe or ball of that substance was sometimes used by the physicians for collecting the rays of the sun, in order to perform the operation of cautery. In another passage, he mentions the power of a glass globe filled with water, to produce a strong heat when exposed to the rays of the sun, and expresses his surprise that the water itself should all the while remain quite cold.

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[1] *Connoissance des Tems*, 1816, p. 245, &c. The glimpses of truth, not destined to be fully discovered till many ages afterwards, which are found in the writings of the ancients, are always interesting. Ptolemy distinguishes what has since been called the *virtual focus*, which takes place in certain cases of reflection, from spherical specula. He remarks, that colours are confounded by the rapidity of motion, and gives the instance of a wheel painted with different colours, and turned quickly round.

[2] Another Greek treatise on optics, that of Heliodorus of Larissa, has been preserved, and was first published by Erasmus Bartholinus at Paris, in 1657. It is a superficial work, which, to a good deal of obscure and unsound metaphysics, adds the demonstration of a few very obvious truths. The author holds the opinion, that vision is performed by the emission of something from the eyes; and the reason which he assigns is, that the eyes are convex, and more adapted to emit than to receive. His metaphysics may be judged of from this specimen. He has not been made mention of by any ancient author, and the time when he wrote is unknown. As he quotes, however, the writings of Ptolemy and Hero, he must have been later than the first century.

[3] The truth of the mathematical proposition, that $\frac{1}{inf.} = 0$, was perceived by Aristotle. A strong intellect is always visible in the midst of his greatest errors.

With respect to the power of glasses to magnify objects seen through them, or to render such objects more distinct, the ancients appear to have observed ill, and to have reasoned worse. "Literæ, quamvis minutæ et obscuræ, per vitream pilam aqua plenam majores clarioresque cernuntur. Sidera ampliora per nubem adspicienti videntur; *quia acies nostra in humido labitur, nec apprehendere quod vult fideliter potest.*"[3] This passage, and the speculations concerning the rainbow in the same place, when they are considered as containing the opinions of some of the most able and best-informed men of antiquity, must be admitted to mark, in a very striking manner, the infancy of the physical sciences.

2. FROM ALHAZEN TO KEPLER.

An interval of nearly a thousand years divided Ptolemy from Alhazen, who, in the history of optical discovery, appears as his immediate successor. This ingenious Arabian lived in the eleventh century, and his merit can be more fairly, and will be more highly appreciated, now that the work of his predecessor has become known. The merit of his book on Optics was always admitted; but he was supposed to have borrowed much from Ptolemy, without acknowledging it; and the prejudices entertained in favour of a Greek author, especially of one who had been for so many years a legislator in science, gave a false impression, both of the genius and the integrity of his modern rival. The work of Alhazen is, nevertheless, in many respects, superior to that of Ptolemy, and in nothing more than in the geometry which it employs. The problem known by his name, to find the point in a spherical speculum, at which a ray coming from one given point shall be reflected to another given point, is very well resolved in his book, though a problem of so much difficulty, that Montucla hazards the opinion, that no Arabian geometer was ever equal to the solution of it.[4] It is now certain, however, that the solution, from whatever quarter it came, was not borrowed from Ptolemy, in whose work no mention is made of any such question; and it may very well be doubted, whether, had this problem been proposed to him, the Greek geometer would have appeared to so much advantage as the Arabian.

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[1] ARISTOPHANIS *Nubes*, v. 766. edit. Brunck.

[2] *Hist. Nat.* lib. xxxvii. cap. ii.

[3] SENECA, *Nat. Quæst.* lib. i. cap. vi.

[4] Barrow, in his 9th lecture, says of this problem, that it may truly be called δυσμηχανον, as hardly any one more difficult had then been attempted by geometers. He adds, that, after trying the analysis in many different ways, he had found nothing preferable to the solution of Alhazen, which he therefore gives, only freed from the prolixness and obscurity with which the original is chargeable. (*Lectiones Opticæ*, sect. 9, p. 65.) A very elegant solution of the same problem is given by Simson, at the end of his *Conic Sections*.

The account which the latter gives of the augmentation of the diameters of the heavenly bodies near the horizon, has been already mentioned. He treated also of the refraction of light by transparent bodies, and particularly of the atmospheric refraction; but not with the precision of Ptolemy, whose optical treatise Delambre seems to think it probable that he had never seen. The anatomical structure of the eye was known to him; concerning the uses of the different parts he had only conjectures to offer; but on seeing single with two eyes, he made this very important remark, that, when corresponding parts of the retina are affected, we perceive but one image.

Prolixity and want of method are the faults of Alhazen. Vitello,[1] a learned Pole, commented on his works, and has very much improved their method and arrangement in a treatise published in 1270. He has also treated more fully of the subject of refraction, and reduced the results of his experiments into the form of a table, exhibiting the angles of refraction corresponding to the angles of incidence, which he had tried in water and glass. It was not, however, till long after this period that the law which connects these angles was discovered. The cause of refraction appeared to him to be the resistance which the rays suffer in passing into the denser medium of water or glass; and one can see in his reasoning an obscure idea of the resolution of forces. He also treats of the rainbow, and remarks, that the altitude of the sun and bow together always amount to 42 degrees. He next considers the structure of the eye, of which he has given a tolerably accurate description; and proves, as Alhazen had before done,[2] that vision is not performed by the emission of rays from the eye.

Roger Bacon, distinguished for pursuing the path of true philosophy in the midst of an age of ignorance and error, belongs to the same period, and applied to the study of optics with peculiar diligence. It does not appear, however, that he added much to the discoveries of Alhazen and Ptolemy, with whose writings, particularly those of the former, he seems to have been well acquainted. In some things he was much behind the Arabian optician, as he supposed, with the ancients, that vision is performed by rays emitted from the eye. It must, however, be allowed, that the arguments employed on both sides of this question are so weak and inconclusive, as very much to diminish the merit of being right, and the demerit of being wrong. What is most to the credit of Bacon, is the near approach he appears to have made to the knowledge of lenses, and their use in assisting vision. Alhazen had remarked, that small objects, letters, for instance, viewed through a segment of a glass sphere, were seen magnified, and that it is the larger segment which magnifies the most. The spherical segment was supposed to be laid with its base on the letters, or other minute objects which were to be viewed. Bacon recommends the smaller segment, and observes, that the greater, though it magnify more, places the object farther off than its natural position, while the other brings it nearer. This shows sufficiently, that he knew how to trace the progress of the rays of light through a spherical transparent body, and understood, what was the thing least obvious, how to determine the place of the image. Smith, in his *Optics*, endeavours to show, that these conclusions were purely theoretical, and that Roger Bacon had never made any experiments with such glasses, notwithstanding that he speaks as if he had done so.[3] This severe remark proceeds on some slight inaccuracy in Bacon's description, which, however, does not seem sufficient to authorize so harsh a conclusion. The probability appears rather to be, as Molineux supposed, that Bacon had made experiments with such glasses, and was both practically and theoretically acquainted with their properties. At the same time, it must be acknowledged, that his credulity on many points, and his fondness for the marvellous, which, with every respect for his talents, it is impossible to deny, take something away from the force of his testimony, except when it is very expressly given. However that may be in the present case, it is probable that the knowledge of the true properties of these glasses, whether it was theoretical or practical, may have had a share in introducing the use of lenses, and in the invention of spectacles, which took place not long after.

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[1] The name of this author is commonly written *Vitellio*. He may be supposed to have known best the orthography of his own name.

[2] ALHAZEN, *Opt.* lib. i.

[3] SMITH'S *Optics*, vol. II. Remarks, sect. 76.

It would be desirable to ascertain the exact period of an invention of such singular utility as this last; one that diffuses its advantages so widely, and that contributes so much to the solace and comfort of old age, by protecting the most intellectual of the senses against the general progress of decay. In the obscurity of a dark age, careless about recording discoveries of which it knew not the principle or the value, a few faint traces and imperfect indications serve only to point out certain limits within which the thing sought for is contained. Seeking for the origin of a discovery, is like seeking for the source of a river where innumerable streams have claims to the honour, between which it is impossible to decide, and where the only thing that can be known with certainty is the boundary by which they are all circumscribed. The reader will find the evidence concerning the invention of spectacles very fully discussed in Smith's *Optics,* from which the most probable conclusion is, that the date goes back to the year 1313, and cannot with any certainty be traced farther.[1]

The lapse of more than two hundred years brings us down to Maurolycus, and to an age when men of science ceased to be so thinly scattered over the wastes of time. Maurolycus, whose knowledge of the pure mathematics has been already mentioned, was distinguished for his skill in optics. He was acquainted with the crystalline lens, and conceived that its office is to transmit to the optic nerve the *species* of external objects; and in this process he does not consider the retina as any way concerned. This theory, though so imperfect, led him nevertheless to form a right judgment of the defects of short-sighted and long-sighted eyes. In one of his first works, *Theoremata de Lumine et Umbra,* he also gives an accurate solution of a question proposed by Aristotle, viz. why the light of the sun, admitted through a small hole, and received on a plane at a certain distance from it, always illuminates a round space, whatever be the figure of the hole itself; whereas, through a large aperture, the illuminated space has the figure of the aperture. To conceive the reason of this, suppose that the figure of the hole is a triangle; it is plain that at each angle the illuminated space will be terminated by a circular arch, of which the centre corresponds to the angular point, and the radius to the angle subtended by the sun's semidiameter. Thus the illuminated space is rounded off at the angles; and when the hole is so small that the size of those roundings bears a large proportion to the distance of their centres, the figure comes near to a circle, and may be to appearance quite round. This is the true solution, and the same with that of Maurolycus. The same author appears also to have observed the caustic curve formed by reflection from a concave speculum.

A considerable step in optical discovery was made at this time by Baptista Porta, a Neapolitan, who invented the *Camera Obscura,* about the year 1560, and described it in a work entitled *Magia Naturalis.* The light was admitted through a small hole in the window-shutter of a dark room, and gave an inverted picture of the objects from which it proceeded, on the opposite wall. A lens was not employed in the first construction of this apparatus, but was afterwards used; and Porta went so far as to consider how the effect might be produced without inversion. He appears to have been a man of great ingenuity; and though much of the *Magia Naturalis* is directed to frivolous objects, it indicates a great familiarity with experiment and observation. It is remarkable, that we find mention made in it of the reflection of cold by a speculum,[2] an experiment which, of late, has drawn so much attention, and has been supposed to be so entirely new. The cold was perceived by making the focus fall on the eye, which, in the absence of the thermometer, was perhaps the best measure of small variations of temperature. Porta's book was extremely popular; and when we find it quickly translated into Italian, French, Spanish, and Arabic, we see how much the love of science was now excited, and what effects the art of printing was now beginning to produce. Baptista Porta was a man of fortune, and his house was so much the resort of the curious and learned at Naples, that it awakened the jealousy with which the court of Rome watched the progress of improvement. How grievous it is to observe the head of the Christian church in that and the succeeding age, like the *Anarch old* in Milton, reigning in the midst of darkness, and complaining of the encroachments which the realm of light was continually making on his ancient empire!

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[1] Smith's *Optics*, vol. II. Remarks, sect. 75.

[2] *Magia Naturalis*, lib. xvii. cap. iv. p. 583. Amsterdam edit. 1664.

The constitution of the eye, and the functions of the different parts of which it consists, were not yet fully understood. Maurolycus had nearly discovered the secret; and it was but a thin, though to him an impenetrable veil, which still concealed one important part of the truth. This veil was drawn aside by the Neapolitan philosopher; but the complete discovery of the truth was left to Kepler, who, to the glory of finding out the true laws of the planetary system, added that of first analyzing the whole scheme of nature in the structure of the eye. He perceived the exact resemblance of this organ to the *dark chamber*, the rays entering the pupil being collected by the crystalline lens, and the other humours of the eye, into *foci*, which paint on the *retina* the inverted images of external objects. By another step of the process, to which our analysis can never be expected to extend, the mind perceives the images thus formed, and refers them at the same time to things without.

It seemed a great difficulty, that, though the images be inverted, the objects are seen erect; but when it is considered that each point in the object is seen in the direction of the line in which the light passes from it to the retina, through the centre of the eye, it will appear that the upright position of the object is a necessary consequence of this arrangement.

Kepler's discovery is explained in his *Paralipomena in Vitellionem*,[1] (Remarks on the Optics of Vitello) a work of great genius, abounding with new and enlarged views, though mixed occasionally with some unsound and visionary speculations. This book appeared in 1604. In the next article we shall have occasion to return to the consideration of other parts of Kepler's optical discoveries.

3. FROM KEPLER TO THE COMMENCEMENT OF NEWTON'S OPTICAL DISCOVERIES.

The rainbow had, from the earliest times, been an object of interest with those who bestowed attention on optical appearances; but it is much too complicated a phenomenon to be easily explained. In general, however, it was understood to arise from light reflected by the drops of rain falling from a cloud opposite to the sun. The difficulty seemed to be, how to account for the colour, which is never produced in white light, such as that of the sun, by mere reflection. Maurolycus advanced a considerable step when he supposed that the light enters the drop, and acquires colour by refraction; but in tracing the course of the ray he was quite bewildered. Others supposed the refraction and the colour to be the effect of one drop, and the reflection of another; so that two refractions and one reflection were employed, but in such a manner as to be still very remote from the truth.

Antonio de Dominis, archbishop of Spalatro, had the good fortune to fall upon the true explanation. Having placed a bottle of water opposite to the sun, and a little above his eye, he saw a beam of light issue from the under side of the bottle, which acquired different colours, in the same order and with the same brilliancy as in the rainbow, when the bottle was a little raised or depressed. From comparing all the circumstances, he perceived that the rays had entered the bottle, and that, after two refractions from the convex part, and a reflection from the concave, they were returned to the eye tinged with different colours, according to the angle at which the ray had entered. The rays that gave the same colour made the same angle with the surface, and hence all the drops that gave the same colour must be arranged in a circle, the centre of which was the point in the cloud opposite to the sun. This, though not a complete theory of the rainbow, and though it left a great deal to occupy the attention, first of Descartes, and afterwards of Newton, was perfectly just, and carried the explanation as far as the principles then understood allowed it to go. The discovery itself may be considered as an anomaly in science, as it is one of a very refined and subtile nature, made by a man who has given no other indication of much scientific sagacity or acuteness. In many things his writings show great ignorance of principles of optics well known in his own time; so that Boscovich, an excellent judge in such matters, has said of him, " homo opticarum rerum, supra id quod patiatur ea ætas, imperitissimus." The book containing this discovery was published in 1611.[1]

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[1] Caput v. *De Modo Visionis.*

A discovery of the same period, but somewhat earlier, will always be considered as among the most remarkable in the whole circle of human knowledge. It is the invention of the telescope, the work in which (by following unconsciously the plan of nature in the formation of the eye) man has come the nearest to the construction of a new organ of sense. For this great invention, in its original form, we are indebted to accident, or to the trials of men who had little knowledge of the principles of the science on which they were conferring so great a favour. A series of scientific improvements, continued for more than two hundred years, has continually added to the perfection of this noble instrument, and has almost entitled science to consider the telescope as its own production.

It will readily be believed, that the origin of such an invention has been abundantly inquired into. The result, however, as is usual in such cases, has not been quite satisfactory; and all that is known with certainty is, that the honour belongs to the town of Middleburg in Zealand, and that the date is between the last ten years of the sixteenth century and the first ten of the seventeenth. Two different workmen belonging to that town, Zachariah Jans and John Lapprey, have testimonies in their favour, between which it is difficult to decide: the former goes back to 1590, the latter comes down to about 1610. It is not of much consequence to settle the priority in a matter which is purely accidental; yet one would not wish to forget or mistake the names of men whom even chance had rendered so great benefactors to science. What we know with certainty is, that the account of the effect produced by this new combination of glasses being carried to Galileo in 1610, led that great philosopher to the construction of the telescope, and to the interesting discoveries already enumerated. By what principle he was guided to the combination, which consists of one convex and one concave lens, he has not explained, and we cannot now exactly ascertain. He had no doubt observed, that a convex lens, such as was common in spectacles, formed images of objects, which were distinctly seen when thrown on a wall or on a screen. He might observe also, that if the image, instead of falling on the screen, were made to fall on the eye, the vision was confused and indistinct. In the trials to remedy this indistinctness by means of another glass, it would be found that a concave lens succeeded when placed before the eye, the eye itself being also a little more advanced than the screen had been.

This instrument, though very imperfect, compared with those which have been since constructed, gave so much satisfaction, that it remained long without any material improvement. Descartes, whose treatise on Optics was written near thirty years after the invention of the telescope, makes no mention of any but such as is composed of a convex object-glass and a concave eye-glass. The theory of it, indeed, was given by Kepler in his *Dioptrics*, in 1611, when he also pointed out the astronomical telescope, or that which is composed of two convex lenses, and inverts the objects. He did not, however, construct a telescope of that kind, which appears to have been first done by *Scheiner*, who has given an account of it in the *Rosa Ursina*, in 1650, quoted by Montucla.[1]

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[1] *De Radiis Lucis in Vitris perspectivis et Iride.* Venetiis, 4to.

After the invention of the telescope, that of the microscope was easy; and it is also to Galileo that we are indebted for this instrument, which discovers an immensity on the one side of man, scarcely less wonderful than that which the telescope discovers on the other. The extension and divisibility of matter are thus rendered to the natural philosopher almost as unlimited as the extension and the divisibility of space are to the geometer.

The theory of the telescope, now become the main object in optical science, required that the law of refraction should, if possible, be accurately ascertained. This had not yet been effected; and Kepler, whose *Dioptrics* was the most perfect treatise on refraction which had yet appeared, had been unable to determine the general principle which connects the angles of incidence and refraction. In the case of glass, he had found by experiment, that those angles, when small, are nearly in the ratio of three to two; and on this hypothesis he had found the focus of a double convex lens, when the curvature of both sides is equal, to be the centre of curvature of the side turned toward the object,—a proposition which is known to coincide with experiment. From the same approximation he derived other conclusions, which were found useful in practice, in the cases where the angles just mentioned were very small.

The discovery of the true law of refraction was the work of Snellius, the same mathematician whose labours concerning the figure of the earth were before mentioned. In order to express this law, he supposed a perpendicular to the refracting surface, at the point where the refraction is made, and also another line parallel to this perpendicular at any given distance from it. The refracted ray, as it proceeds, will meet this parallel, and the incident ray is supposed to be produced, till it do so likewise. Now, the general truth which Snellius found to hold, whatever was the position of the incident ray, is, that the segments of the refracted ray and of the incident ray, intercepted by these parallels, had always the same ratio to one another. If either of the media were changed, that through which the incident ray, or that through which the refracted ray passed, this ratio would be changed; but while the media remained the same, the ratio continued unalterable. It is seldom that a general truth is seen at first under the most simple aspect: this law admits of being more simply expressed; for, in the triangle formed by the two segments of the rays, and by the parallel which they intersect, the said segments have the same ratio with the sines of the opposite angles, that is, with the sines of the angles of incidence and refraction. The law, therefore, comes to this, that, in the refraction of light by the same medium, the sine of the angle of incidence has to the sine of the angle of refraction always the same ratio. This last simplification did not occur to Snellius; it is the work of Descartes, and was first given in his *Dioptrics*, in 1637, where no mention is made of Snellius, and the law of refraction appears as the discovery of the author. This naturally gave rise to heavy charges against the candour and integrity of the French philosopher. The work of Snellius had never been published, and the author himself was dead; but the proposition just referred to had been communicated to his friends, and had been taught by his countryman Professor Hortensius, in his lectures. There is no doubt, therefore, that the discovery was first made by Snellius; but whether Descartes derived it from him, or was himself the second discoverer, remains undecided. The question is one of those, where a man's conduct in a particular situation can only be rightly interpreted from his general character and behaviour. If Descartes had been uniformly fair and candid in his intercourse with others, one would have rejected with disdain a suspicion of the kind just mentioned. But the truth is, that he appears throughout a jealous and suspicious man, always inclined to depress and conceal the merit of others. In speaking of the inventor of the telescope, he has told minutely all that is due to accident, but has passed carefully over all that proceeded from design, and has incurred the reproach of relating the origin of that instrument, without mentioning the name of Galileo. In the same manner, he omits to speak of the discoveries of Kepler, so nearly connected with his own; and in treating of the rainbow, he has made no mention of Antonio de Dominis. It is impossible that all this should not produce an unfavourable impression; and hence it is, that even the warmest admirers of Descartes do not pretend that his conduct toward Snellius can be completely justified.

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[1] Vol. II. p. 234. 2d edit.

Descartes would have conceived his philosophy to be disgraced if it had borrowed any general principle from experience, and he therefore derived, or affected to derive, the law of refraction from reasoning or from theory. In this reasoning there were so many arbitrary suppositions concerning the nature of light, and the action of transparent bodies, that no confidence can be placed in the conclusions deduced from it. It is indeed quite evident that, independently of experiment, Descartes himself could have put no trust in it; and it is impossible not to feel how much more it would have been for the credit of that philosopher to have fairly confessed that the knowledge of the law was from experiment, and that the business of theory was to deduce from thence some inferences with respect to the constitution of light and of transparent bodies. This I conceive to be the true method of philosophizing, but it is the reverse of that which Descartes pursued on all occasions.

The weakness of his reasoning was perceived and attacked by Fermat, who, at the same time, was not very fortunate in the theory which he proposed to substitute for that of his rival. The latter had laid it down as certain, that light, of which he supposed the velocity infinite, or the propagation instantaneous, meets with less obstruction in dense than in rare bodies, for which reason, it is refracted toward the perpendicular, in passing from the latter into the former. This seemed to Fermat a very improbable supposition, and he conceived the contrary to be true, viz. that light in rare bodies has less obstruction, and moves with greater velocity, than in dense bodies. On this supposition, and appealing, not to physical, but to final causes, Fermat imagined to himself that he could deduce the true law of refraction. He conceived it to be a fact that light moves always between two points, so as to go from the one to the other in the least time possible. Hence, in order to pass from a given point in a rarer medium where it moves faster, to a given point in a denser medium where it moves slower, so that the time may be a *minimum*, it must continue longer in the former medium than if it held a rectilineal course; and the bending of its path, on entering the latter, will therefore be toward the perpendicular. On instituting the calculus, according to his own doctrine of *maxima* and *minima*, Fermat found, to his surprise, that the path of the ray must be such, that the sines of the angles of incidence and refraction have a constant ratio to one another. Thus did these philosophers, setting out from suppositions entirely contrary, and following routes which only agreed in being quite unphilosophical and arbitrary, arrive, by a very unexpected coincidence, at the same conclusion. Fermat could no longer deny the law of refraction, as laid down by Descartes; but he was less than ever disposed to admit the justness of his reasoning.

Descartes proceeded from this to a problem which, though suggested by optical considerations, was purely geometrical, and in which his researches were completely successful. It was well known that, in the ordinary cases of refraction by spherical and other surfaces, the rays are not collected into one point, but have their foci spread over a certain surface, the sections of which are the curves called caustic curves; and that the focus of opticians is only a point in this surface, where the rays are more condensed, and, of course, the illumination more intense, than in other parts of it. It is plain, however, that if refraction is to be employed, either for the purpose of producing light or heat, it would be a great advantage to have all the rays which come from the same point of an object united accurately, after refraction, in the same point of the image. This gave rise to an inquiry into the figure which the superficies, separating two transparent media of different refracting powers, must have, in order that all the rays diverging from a given point might, by refraction at the said superficies, be made to converge to another given point.[1] The problem was resolved by Descartes in its full extent; and he proved that the curves, proper for generating such superficies by their revolution, are all comprehended under one general character, viz. that there are always two given points, from which, if straight lines be drawn to any point in the curve, the one of these, *plus* or *minus*, that which has a given ratio to the other, is equal to a given line.

It is evident, when the given ratio here mentioned is a ratio of equality, that the curve is a conic section, and the two given points its two foci. The curves, in general, are of the fourth or the second order, and have been distinguished by the name of the ovals of Descartes.

From this very ingenious investigation, no practical result of advantage in the construction of lenses has been derived. The mechanical difficulties of working a superficies into any figure but a spherical one are so great, that, notwithstanding all the efforts of Descartes himself and of many of his followers, they have never been overcome; so that the great improvements in optical instruments have arisen in a quarter entirely different.

Descartes gave also a full explanation of the rainbow,[2] as far as colour was not concerned; a part of the problem which remained for Newton to resolve. The path of the ray was traced, and the angles of the incident ray, with that which emerges after two refractions and one reflection, were accurately determined. Descartes paid little attention to those who had gone before him, and, as already remarked, never once mentioned the archbishop of Spalatro. Like Aristotle, he seems to have formed the design of cutting off the memory of all his predecessors; but the invention of printing had made this a far more hopeless undertaking than it was in the days of the Greek philosopher.

After the publication of the *Dioptrics* of Descartes, in 1637, a considerable interval took place, during which optics, and indeed science in general, made but little progress, till the *Optica Promota* of James Gregory, in 1663, seemed to put them again in motion. The author of this work, a profound and inventive geometer, had applied diligently to the study of optics and the improvement of optical instruments. The *Optica Promota* embraced several new inquiries concerning the illumination and distinctness of the images formed in the foci of lenses, and contained an account of the reflecting telescope, still known by the name of its author. The consideration which suggested this instrument was the imperfection of the images formed by spherical lenses, in consequence of which, they are not in plane, but in curved surfaces. The desire of removing this imperfection led Gregory to substitute reflection for refraction in the construction of telescopes; and by this means, while he was seeking to remedy a small evil, he provided the means of avoiding a much greater one, with which he was not yet acquainted, viz. that which arises from the unequal refrangibility of light. The attention of Newton was about the same time drawn to the same subject, but with a perfect knowledge of the defect which he wanted to remove. Gregory thought it necessary that the specula should be of a parabolic figure; and the execution proved so difficult, that the instrument, during his own life, was never brought to any perfection. The specula were afterwards constructed of the ordinary spherical form, and the Gregorian telescope, till the time of Dr Herschel, was more in use than the Newtonian.

Gregory was Professor of Mathematics at St Andrews, and afterwards for a short time at Edinburgh. His writings strongly mark the imperfect intercourse which subsisted at that time between this country and the Continent. Though the *Optics* of Descartes had been published twenty-five years, Gregory had not heard of the discovery of the law of refraction, and had found it out only by his own efforts;—happy in being able, by the fertility of his genius, to supply the defects of an insulated and remote situation.

A course of lectures on optics, delivered at

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[1] Cartesii *Dioptrice*, cap. viii.; *Geometria*, lib. ii.

[2] *Meteora*, cap. viii.

Cambridge in 1668, by Dr Barrow, and published in the year following, treated of all the more difficult questions which had occurred in that state of the science, with the acuteness and depth which are found in all the writings of that geometer. This work contains some new views in optics, and a great deal of profound mathematical discussion.

About this time Grimaldi, a learned Jesuit, the companion of Riccioli, in his astronomical labours, made known some optical phenomena which had hitherto escaped observation. They respected the action of bodies on light, and when compared with reflection and refraction, might be called, in the language of Bacon's philosophy, *crepuscular* instances, indicating an action of the same kind, but much weaker and less perceptible. Having stretched a hair across a sunbeam, admitted through a hole in the window-shutter of a dark chamber, he was surprised to find the shadow much larger than the natural divergence of the rays could have led him to expect. Other facts of the same kind made known the general law of the *diffraction* or *inflection* of light, and showed that the rays are acted on by bodies, and turned out of their rectilineal course, even when not in contact, but at a measurable distance from the surfaces or edges of such bodies. Grimaldi gave an account of those facts in a treatise printed at Bologna in 1665.[1]

Optics, as indeed all the branches of Natural Philosophy, have great obligations to Huygens. The former was among the first scientific objects which occupied his mind; and his *Dioptrics*, though a posthumous work, is most of it the composition of his early youth. It is written with great perspicuity and precision, and is said to have been a favourite book with Newton himself. Though beginning from the first elements, it contains a full development of the matters of greatest difficulty in the construction of telescopes, particularly in what concerns the indistinctness arising from the imperfect foci into which rays are united by spherical lenses; and rules are deduced for constructing telescopes, which, though of different sizes, shall have the same degree of distinctness, illumination, &c. Huygens was, besides, a practical optician; he polished lenses and constructed telescopes with his own hands, and some of his object-glasses were of the enormous focal distance of 130 feet. To his *Dioptrics* is added a valuable treatise *De Formandis Vitris.*

In the history of optics, particular attention is due to his theory of light, which was first communicated to the Academy of Sciences of Paris, in 1678, and afterwards published, with enlargements, in 1690.[2]

Light, according to this ingenious system, consists in certain undulations communicated by luminous bodies to the ethereal fluid which fills all space. This fluid is composed of the most subtile matter, is highly elastic, and the undulations are propagated through it with great velocity in spherical superficies proceeding from a centre. Light, in this view of it, differs from that of the Cartesian system, which is supposed to be without elasticity, and to convey impressions instantaneously, as a staff does from the object it touches to the hand which holds it.

It is not, however, in this general view that the ingenuity of the theory appears, but in its application to explain the equality of the angles of incidence and reflection; and, most of all, the constant ratio which subsists between the sines of the angles of incidence and of refraction. Few things are to be met with more simple and beautiful than this last application of the theory; but that which is most remarkable of all is, the use made of it to explain the double refraction of Iceland crystal. This crystal, which is no other than the calcareous spar of mineralogists, has not only the property of refracting light in the usual manner of glass, water, and other transparent bodies, but it has also another power of refraction, by which even the rays falling perpendicularly on the surface of the crystal are turned out of their course, so that a double image is formed of all objects seen through these crystals. This property belongs not only to calcareous spar, but, in a greater or less degree, to all substances which are both crystallized and transparent.

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[1] *Physico-Mathesis de Lumine, Coloribus, &c.* 4to.
[2] *Traité de la Lumière.* Leyde, 1690.

The common refraction is explained by Huygens, on the supposition that the undulations in the luminous fluid are propagated in the form of spherical waves. The double refraction is explained on the supposition that the undulations of light, in passing through the calcareous spar, assume a spheroidal form; and this hypothesis, though it does not apply with the same simplicity as the former, yet admits of such precision, that a proportion of the axes of the spheroids may be assigned, which will account for the precise quantity of the extraordinary refraction, and for all the phenomena dependent on it, which Huygens had studied with great care, and had reduced to the smallest number of general facts. That these spheroidal undulations actually exist, he would, after all, be a bold theorist who should affirm; but, that the supposition of their existence is an accurate expression of the phenomena of double refraction, cannot be doubted. When one enunciates the hypothesis of the spheroidal undulations, he, in fact, expresses in a single sentence all the phenomena of double refraction. The hypothesis is therefore the means of representing these phenomena, and the laws which they obey, to the imagination or the understanding; and there is perhaps no theory in optics, and but very few in natural philosophy, of which more can be said. Theory, therefore, in this instance, is merely to be regarded as the expression of a general law; and in that light, I think, it is considered by Laplace.

To carry the theory of Huygens farther, and to render it quite satisfactory, a reason ought to be assigned why the undulations of the luminous fluid are spheroidal in the case of crystals, and spherical in all other cases. This would be to render the generalization more complete; and till that is done, and a connection clearly established between the structure of crystallized bodies and the property of double refraction, the theory will remain imperfect. The attention which at present is given to this most singular and interesting branch of optics, and the great number of new phenomena observed and classed under the head of the *Polarisation of Light*, make it almost certain that this object will be either speedily accomplished, or that science has here reached one of the immovable barriers by which the circle of human knowledge is to be for ever circumscribed.

DISSERTATION FOURTH.

PART SECOND.

FROM THE COMMENCEMENT OF NEWTON'S DISCOVERIES TO THE YEAR 1818.

In the former part of this sketch, the history of each division of the sciences was continued without interruption, from the beginning to the end. During the period, however, on which I am now to enter, the advancement of knowledge has been so rapid, and marked by such distinct steps, that several pauses or resting-places occur, of which it may be advisable to take advantage. Were the history of any particular science to be continued for the whole of the busy interval which this second part embraces, it would leave the other sciences too far behind, and would make it difficult to perceive the mutual action by which they have so much assisted the progress of one another. Considering some sort of subdivision, therefore, as necessary, and observing, in the interval which extends from the first of Newton's discoveries to the year 1818, three different conditions of the Physico-Mathematical sciences, well marked and distinguished by great improvements, I have divided the above interval into three corresponding parts. The first of these, reaching from the commencement of Newton's discoveries in 1663, to a little beyond his death, or to 1730, may be denominated, from the men who impressed on it its peculiar character, the period of Newton and Leibnitz. The second, which, for a similar reason, I call that of Euler and D'Alembert, may be regarded as extending from 1730 to 1780; and the third, that of Lagrange and Laplace, from 1780 to 1818.

PERIOD FIRST.

SECTION I.

THE NEW GEOMETRY.

The seventeenth century, which had advanced with such spirit and success in combating prejudice, detecting error, and establishing truth, was destined to conclude with the most splendid series of philosophical discoveries yet recorded in the history of letters. It was about to witness, in succession, the invention of Fluxions, the discovery of the Composition of Light, and of the Principle of Universal Gravitation,—all three within a period of little more than twenty years, and all three the work of the same individual. It is to the first of these that our attention at present is to be particularly directed.

The notion of Infinite Quantity had, as we have already seen, been for some time introduced into geometry, and having become a subject of reasoning and calculation, had, in many instances, after facilitating the process of both, led to conclusions from which, as if by magic, the idea of infinity had entirely disappeared, and left the geometer or the algebraist in possession of valuable propositions, in which were involved no magnitudes but such as could be readily exhibited. The discovery of such results had increased both the interest and extent of mathematical investigation.

It was in this state of the sciences that Newton began his mathematical studies, and, after a very short interval, his mathematical discoveries.[1] The book, next to the elements, which was put into his hands, was Wallis's *Arithmetic of Infinites*, a work well fitted for suggesting new views in geometry, and calling into activity the powers of mathematical invention. Wallis had effected the quadrature of all those curves in which the value of one of the co-ordinates can be expressed in terms of the other, without involving either fractional or negative exponents. Beyond this point, neither his researches nor those of any other geometer had yet reached, and from this point the discoveries of Newton began. The Savilian professor had himself been extremely desirous to advance into the new region, where, among other great objects, the quadrature of the circle must necessarily be contained; and he made a very noble effort to pass the barrier by which the undiscovered country appeared to be defended. He saw plainly, that if the equations of the curves which he had squared were ranged in a regular series, from the simpler to the more complex, their areas would constitute another corresponding series, the terms of which were all known. He further remarked, that, in the first of these series, the equation to the circle itself might be introduced, and would occupy the middle place between the first and second terms of the series, or between an equation to a straight line and an equation to the common parabola. He concluded therefore, that if, in the second series, he could interpolate a term in the middle, between its first and second terms, this term must necessarily be no other than the area of the circle. But when he proceeded to pursue this very refined and philosophical idea, he was not so fortunate; and his attempt toward the requisite interpolation, though it did not entirely fail, and made known a curious property of the area of the circle, did not lead to an indefinite quadrature of that curve.[2] Newton was much more judicious and successful in his attempt. Proceeding on the same general principle with Wallis, as he himself tells us, the simple view which he took of the areas already computed, and of the terms of which each consisted, enabled him to discover the law which was common to them all, and under which the expression for the area of the circle, as well as of innumerable other curves, must needs be comprehended. In the case of the circle, as in all those where a fractional exponent appeared, the area was exhibited in the form of an infinite series.

The problem of the quadrature of the circle, and of so many other curves, being thus resolved, Newton immediately remarked, that the law of these series was, with a small alteration, the law for the series of terms which expresses the root of any binomial quantity whatsoever. Thus he was put in possession of another valuable discovery, the Binomial Theorem, and at the same time perceived that this last was in reality, in the order of things, placed before the other, and afforded a much easier access to such quadratures than the method of interpolation, which, though the first road, appeared now neither to be the easiest nor the most direct.

It is but rarely that we can lay hold with certainty of the thread by which genius has been guided in its first discoveries. Here we are proceeding on the authority of the author himself; for in a letter to Oldenburg,[1] Secretary of the Royal Society of London, he has entered into considerable detail on this subject, adding, (so ready are the steps of invention to be forgotten) that the facts would have entirely escaped his memory, if he had not been reminded of them by some notes which he had made at the time, and which he had accidentally fallen on. The whole of the letter just referred to is one of the most valuable documents to be found in the history of invention.

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[1] He entered at Trinity College, Cambridge, in June 1660. The date of his first discoveries is about 1663.

[2] The interpolation of Wallis failed, because he did not employ literal or general exponents. His theorem, expressing the area of the entire circle by a fraction, of which the numerator and denominator are each the continued product of a certain series of numbers, is a remarkable anticipation of some of Euler's discoveries. (*Calc. Int.* tom. I. cap. viii.)

In all this, however, nothing occurs from which it can be inferred that the method of fluxions had yet occurred to the inventor. His discovery consisted in the method of reducing the value of y, the ordinate of a curve, into an infinite series of the integer powers of x the abscissa, by division, or the extraction of roots, that is, by the Binomial Theorem; after which, the part of the area belonging to each term could be assigned by the arithmetic of infinites, or other methods already known. He has assured us himself, however, that the great principle of the new geometry was known to him, and applied to investigation, as early as 1665 or 1666.[2] Independently of that authority, we also know, on the testimony of Barrow, that soon after the period just mentioned there was put into his hands by Newton a manuscript treatise,[3] the same which was afterwards published under the title of *Analysis per Æquationes Numero Terminorum Infinitas*, in which, though the instrument of investigation is nothing else than infinite series, the principle of fluxions, if not fully explained, is at least distinctly pointed out. Barrow strongly exhorted his young friend to publish this treasure to the world; but the modesty of the author, of which the excess, if not culpable, was certainly in the present instance very unfortunate, prevented his compliance. All this was previous to the year 1669; the treatise itself was not published till 1711, more than forty years after it was written.

For a long time, therefore, the discoveries of Newton were only known to his friends; and the first work in which he communicated any thing to the world on the subject of fluxions was in the first edition of the *Principia*, in 1687, in the second *Lemma* of the second book, to which, in the disputes that have since arisen about the invention of the new analysis, reference has been so often made. The principle of the fluxionary calculus was there pointed out, but nothing appeared that indicated the peculiar algorithm, or the new notation, which is so essential to that calculus. About this Newton had yet given no information; and it was only from the second volume of Wallis's Works, in 1693, that it became known to the world.[4] It was no less than ten years after this, in 1704, that Newton himself first published a work on the new calculus, his *Quadrature of Curves*, more than twenty-eight years after it was written.

These discoveries, however, even before the press was employed as their vehicle, could not remain altogether unknown in a country where the mathematical sciences were cultivated with zeal and diligence. Barrow, to whom they were first made known by the author himself, communicated them to Oldenburg, the Secretary of the Royal Society, who had a very extensive correspondence all over Europe. By him the series for the quadrature of the circle were made known to James Gregory, in Scotland, who had occupied himself very much with the same subject. They were also communicated to Leibnitz in Germany, who had become acquainted with Oldenburg in a visit which he made to England in 1673. At the time of that visit, Leibnitz was but little conversant with the Mathematics; but having afterwards devoted his great talents to the study of that science, he was soon in a condition to make new discoveries. He invented a method of squaring the circle, by transforming it into another curve of an equal area, but having the ordinate expressed by a rational fraction of the absciss, so that its area could be found by the methods already known. In this way he discovered the series, so remarkable for its simplicity, which gives the value of a circular arch in terms of the tangent. This series he communicated to Oldenburg in 1674, and received from him in return an account of the progress made by Newton and Gregory in the invention of series. In 1676, Newton described his method of quadratures at the request of Oldenburg, in order that it might be transmitted to Leibnitz, in the two letters already mentioned, as of such value, by recording the views which guided that great geometer in his earliest, and some of his most important discoveries. The method of fluxions is not communicated in these letters; nor are the principles of it in any way suggested; though there are, in the last letter, two sentences in transposed characters, which ascertain that Newton was then in possession of that method, and employed in speaking of it the same language in which it was afterwards made known. In the following year, Leibnitz, in a letter to Oldenburg, introduces differentials, and the methods of his calculus, for the first time. This letter,[1] which is very important, clearly proves that the author was then in full possession of the principles of his calculus, and had even invented the algorithm and notation.

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[1] *Commercium Epistolicum*, No. 55.

[2] *Quadrature of Curves*, Introduction.

[3] *Commercium Epistolicum*, No. I. II. III. &c.

[4] Wallis says, that he had inserted in the English edition of his book, published in 1685, several extracts from Newton's *Letters*, "*Omissis multis aliis inibi notatu dignis, eo quod speraverim clarissimum virum voluisse tum illa, tum alia quæ apud ipsum premit, edidisse. Cum vero illud nondum fecerit, libet eorum nonnulla hic attingere, ne pereant.*" Among these last is an account of the fluxionary notation, according to which the fluxions of flowing quantities are distinguished by points, and also of certain applications of this new algorithm, extracted from two letters of Newton, written in 1792. (*Opera*, tom. II. p. 390, &c.) There is no evidence of his notation having existed earlier than that date, though it be highly probable that it did.

From these facts, and they are all that bear directly on the question concerning the invention of the infinitesimal analysis, if they be fairly and dispassionately examined, I think that no doubt can remain that Newton was the first inventor of that analysis, which he called by the name of Fluxions; but that, in the communications made by him, or his friends, to Leibnitz, there was nothing that could convey any idea of the principle on which that analysis was founded, or of the algorithm which it involved. The things stated were merely results; and though some of those relating to the tangents of curves might show the author to be in possession of a method of investigation different from infinite series, yet they afforded no indication of the nature of that method, or the principles on which it proceeded.

In what manner Newton's communications in the two letters already referred to may have acted in stimulating the curiosity, and extending, or even directing, the views of such a man as Leibnitz, I shall not presume to decide (nor, even if such effect be admitted, will it take from the originality of his discoveries); but, that in the authenticated communications which took place between these philosophers there was nothing which could make known the nature of the fluxionary calculus, I consider as a fact most fully established.

Of the new or infinitesimal analysis, we are, therefore, to consider Newton as the first inventor, Leibnitz as the second; his discovery, though posterior in time, having been made independently of the other, and having no less claim to originality. It had the advantage also of being first made known to the world; an account of it, and of its peculiar algorithm, having been inserted in the first volume of the *Acta Eruditorum*, in 1684. Thus, while Newton's discovery remained a secret, communicated only to a few friends, the geometry of Leibnitz was spreading with great rapidity over the Continent. Two most able coadjutors, the brothers James and John Bernoulli, joined their talents to those of the original inventor, and illustrated the new methods by the solution of a great variety of difficult and interesting problems. The reserve of Newton still kept his countrymen ignorant of his geometrical discoveries; and the first book that appeared in England on the new geometry was that of Craig, who professedly derived his knowledge from the writings of Leibnitz and his friends. Nothing, however, like rivalship or hostility between these inventors had yet appeared; each seemed willing to admit the originality of the other's discoveries; and Newton, in the passage of the *Principia* just referred to, gave a highly favourable opinion on the subject of the discoveries of Leibnitz.

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[1] *Commercium Epistolicum*, No. 66.

The quiet, however, that now prevailed between the English and German philosophers, was clearly of a nature to be easily disturbed. With the English was conviction, and, as we have seen, a well-grounded conviction, that the first discovery of the infinitesimal analysis was the property of Newton; but the analysis thus discovered was yet unknown to the public, and was in the hands of the inventor and his friends. With the Germans there was the conviction, also well founded, that the invention of their countryman was perfectly original; and they had the satisfaction to see his calculus everywhere adopted, and himself considered all over the Continent as the sole inventor. The friends of Newton could not but resist this latter claim; and the friends of Leibnitz, seeing that their master had become the great teacher of the new calculus, could not easily bring themselves to acknowledge that he was not the first discoverer. The tranquillity that existed under such circumstances, if once disturbed, was not likely to be speedily restored.

Accordingly, a remark of Fatio de Duillier, a mathematician, not otherwise very remarkable, was sufficient to light up a flame which a whole century has been hardly sufficient to extinguish. In a paper on the line of swiftest descent, which he presented to the Royal Society in 1699, was this sentence: "I hold Newton to have been the first inventor of this calculus, and the earliest, by several years, induced by the evidence of facts; and whether Leibnitz, the second inventor, has borrowed any thing from the other, I leave to the judgment of those who have seen the letters and manuscripts of Newton." Leibnitz replied to this charge in the Leipsic *Journal*, without any asperity, simply stating himself to have been, as well as Newton, the inventor; neither contesting nor acknowledging Newton's claim to priority, but asserting his own to the first publication of the calculus.

Not long after this, the publication of Newton's *Quadrature of Curves*, and his *Enumeration of the lines of the third order*, (1705) afforded the same journalists an opportunity of showing their determination to retort the insinuations of Duillier, and to carry the war into the country of the enemy. After giving a very imperfect synopsis of the first of these books, they add: "*Pro differentiis igitur Leibnitianis D. Newtonus adhibet, semperque adhibuit, fluxiones; quæ sunt quam proxime ut fluentium augmenta, æqualibus temporis particulis quam minimis genita; iisque, tum in suis Principiis Naturæ Mathematicis, tum in aliis postea editis, eleganter est usus; quemadmodum Honoratus Fabrius in sua Synopsi Geometrica motuum progressus Cavalierianæ methodo substituit.*"[1]

In spite of the politeness and ambiguity of this passage, the most obvious meaning appeared to be, that Newton had been led to the notion of fluxions by the differentials of Leibnitz, just as Honoratus Fabri had been led to substitute the idea of progressive motion for the indivisibles of Cavalieri. A charge so entirely unfounded, so inconsistent with acknowledged facts, and so little consonant to declarations that had formerly come from the same quarter, could not but call forth the indignation of Newton and his friends, especially as it was known that these journalists spoke the language of Leibnitz and Bernoulli. In that indignation they were perfectly justified; but when the minds of contending parties have become irritated in a certain degree, it often happens that the injustice of one side is retaliated by an equal injustice from the opposite. Accordingly, Keill, who, with more zeal than judgment, undertook the defence of Newton's claims, instead of endeavouring to establish the priority of his discoveries by an appeal to facts and to dates that could be accurately ascertained, (in which he would have been completely successful) undertook to prove, that the communications of Newton to Leibnitz were sufficient to put the latter in possession of the principles of the new analysis, after which he had only to substitute the notion of differentials for that of fluxions. In support of a charge which it would have required the clearest and most irresistible evidence to justify, he had, however, nothing to offer but equivocal facts and overstrained arguments, such as could only convince those who were already disposed to believe. They were, accordingly, received as sound reasoning in England, rejected as absurd in Germany, and read with no effect by the mathematicians of France and Italy.

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[1] *Commercium Epistolicum*, No. 79: NEWTONI *Opera*, tom. IV. p. 577.

Leibnitz complained of Keill's proceeding to the Royal Society of London, which declined giving judgment, but appointed a commission of its members to draw up a full and detailed report of all the communications which had passed between Newton and Leibnitz, or their friends, on subjects connected with the new analysis, from the time of Collins and Oldenburg to the date of Keill's letter to Sir Hans Sloane in 1711, the same that was now complained of. This report forms what is called the *Commercium Epistolicum;* it was published by order of the Royal Society the year following, and contains an account of the facts, which, though in the main fair and just, does not give that impression of the impartiality of the reporters which the circumstances so imperiously demanded. Leibnitz complained of this publication, and alleged, that though nothing might be inserted that was not contained in the original letters, yet certain passages were suppressed which were favourable to his pretensions. He threatened an answer, which, however, never appeared. Some notes were added to the *Commercium,* which contain a good deal of asperity and unsupported insinuation. The *Recensio,* or review of it, inserted in the *Philosophical Transactions* for 1715, though written with ability, is still more liable to the same censure.

In the year (1713) which followed the publication of the *Commercium Epistolicum,* a paragraph was circulated among the mathematicians of Europe, purporting to be the *judgment of a mathematician* on the invention of the new analysis. The author was not named, but was generally understood to be John Bernoulli, of which, indeed, the terms in which Leibnitz speaks of the judgment leave no room to doubt. Bernoulli was without question well acquainted with the subject in dispute; he was a perfect master of the calculus; he had been one of the great instruments of its advancement; and, except impartiality, possessed every requisite for a judge. Without offence it might be said, that he could scarcely be accounted impartial. He had been a party in all that had happened. Warmly attached as he was to the one side, and greatly exasperated against the other, his temper had been more frequently ruffled, and his passions or prejudices more violently excited, than those of any other individual. With all his abilities, therefore, he was not likely to prove the fairest and most candid judge, in a cause that might almost be considered as his own. His sentence, however, is pronounced in calm and temperate language, and amounts to this, *That there is no reason to believe that the fluxionary calculus was invented before the differential.* The friends of Leibnitz hurt their own cause, by attempting to fix on Newton a charge of plagiarism, which was refuted by such a chain of evidence, by so many dates distinctly ascertained, and so many concessions of their own. A candid review of the evidence led to the conviction, that both Newton and Leibnitz were original inventors. When the English mathematicians accused Leibnitz of borrowing from Newton, they were, therefore, going much farther than the evidence authorized them, and were mistaking their own partialities for proofs. They maintained what was not true, but what, nevertheless, was not physically impossible, the discovery of Newton being certainly prior to that of Leibnitz. The German mathematicians, on the other hand, when they charged Newton with borrowing from Leibnitz, were maintaining what was not only false, but what involved an impossibility. This is the only part of the dispute, in which any thing that could be construed into *mala fides* can be said to have appeared. I am far, however, from giving it that construction; men of such high character, both for integrity and talents, as Leibnitz and Bernoulli, ought not to be lightly subjected to so cruel an imputation. Partiality, prejudice, and passion, are sufficient to account for much injustice, without a decided intention to do wrong.

In the state of hostility to which matters were now brought, the new analysis itself was had recourse to, as affording to either side abundant means of annoying its adversaries, by an inexhaustible supply of problems, accessible to those alone who were initiated in the doctrines, and who could command the resources of that analysis. The power of resolving such problems, therefore, seemed a test whether this analysis was understood or not. Already some questions of this kind had been proposed in the Leipsic *Journal*, not as defiances, but as exercises in the new geometry. Such was the problem of the *Catenaria*, or the curve, which a chain of uniform weight makes when suspended from two points. This had been proposed by Bernoulli in 1690, and had been resolved by Huygens, Leibnitz, and himself.

A question had been proposed, also, concerning the line of swiftest descent, in 1697, or the line along which a body must descend, in order to go from one point to another not perpendicularly under it, in the least time possible. Though a straight line be the shortest distance between two points, it does not necessarily follow that the descent in that line will be most speedily performed; for, by falling in a curve that has at first a very rapid declivity, the body may acquire in the beginning of its motion so great a velocity, as shall carry it over a long line in less time than it would describe a short one, with a velocity more slowly acquired. This, however, is a problem that belongs to a class of questions of peculiar difficulty; and accordingly it was resolved only by a few of the most distinguished mathematicians. The solutions which appeared within the time prescribed were from Leibnitz, Newton, the two Bernoullis, and M. de l'Hopital. Newton's appeared in the *Philosophical Transactions* without a name; but the author was easily recognised. John Bernoulli, on seeing it, is said to have exclaimed, *Ex ungue leonem!*

The curve that has the property required is the cycloid: Newton has given the construction, but has not accompanied it with the analysis. He added afterwards the demonstration of a very curious theorem for determining the time of the actual descent. Leibnitz resolved the problem the same day that he received the *programme* in which it was proposed.

The problem of orthogonal trajectories, as it is called, had been long ago proposed in the *Acta Eruditorum*, with an invitation to all who were skilled in the new analysis to attempt the solution. The problem had not, at first, met with the attention it was supposed to deserve; but John Bernoulli, having resumed the consideration of it, found out what appeared a very perfect and very general solution; and the question was then (1716) proposed anew by Leibnitz, for the avowed purpose of trying the skill of the English mathematicians. The question is,—a system of curves described according to a known law being given, (all the hyperbolas, for instance, that are described between the same assymptotes, or all the parabolas that have the same directrix, and that pass through the same point, &c.) to describe a curve which shall cut them all at right angles. This may be considered as the first defiance professedly aimed at the English mathematicians. The problem was delivered to Newton on his return from the Mint, when he was much fatigued with the business of the day: he resolved it, however, the same evening; and his solution, though without a name, is given in the *Philosophical Transactions* for 1716.[1]

This solution, however, only gave rise to new quarrels; for hardly any thing so excellent could come from the one side, that it could meet with the entire approbation of the other. Newton's, indeed, was rather the plan or *projet* of an investigation, than an actual solution; and, in the general view which it took of the question, could hardly provide against all the difficulties that might occur in the application to particular cases. This was what Bernoulli objected to, and affected to treat the solution as of no value. Brook Taylor, Secretary of the Royal Society, and well known as one of the ablest geometers of the time, undertook the defence of it, but concluded with using language very reprehensible, and highly improper to be directed by one man of science against another. Having sufficiently, as he supposed, replied to Bernoulli and his friends, he adds, "if they are not satisfied with the solution, it must be ascribed to *their own ignorance*."[2] It strongly marks the temper by which both sides were now animated, when a man like Taylor, eminent for profound science, and, in general, very much disposed to do justice to the merits of others, should so forget himself as to reproach with ignorance of the calculus one of the men who understood it the best, and who had contributed the most to its improvement. The irritability and prejudices of Bernoulli admitted of no defence, and he might very well have been accused of viewing the solution of Newton through a medium disturbed by their action; but to suppose that he was unable to understand it, was an impertinence that could only react on the person who was guilty of it. Bernoulli was not exemplary for his patience; and it will be readily believed, that the incivility of Taylor was sufficiently revenged. It is painful to see men of science engaged in such degrading altercation; and I should be inclined to turn from so disagreeable an object, if the bad effects of the spirit thus excited were not such as must again obtrude themselves on the notice of the reader.

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[1] Vol. XXIX. p. 399.

[2] Eorum imperitiæ tribuendum est.

Taylor not long after came forward with an open defiance to the whole Continent, and proposed a problem, *Omnibus geometris non Anglis*,—a problem, of course, which he supposed that the English mathematicians alone were sufficiently enlightened to resolve. He selected one, accordingly, of very considerable difficulty,—the integration of a fluxion of a complicated form; which, nevertheless, admitted of being done in a very elegant manner, known, I believe, at that time to very few of the English mathematicians,—to Cotes, to himself, and perhaps one or two more. The selection, nevertheless, was abundantly injudicious; for Bernoulli, as long ago as 1702, had explained the method of integrating this, and such like formulas, both in the Paris *Mémoires* and in the Leipsic *Acts*. The question, accordingly, was no sooner proposed than it was answered in a manner the most clear and satisfactory; so the defiance of Taylor only served to display the address and augment the triumph of his adversary.

The last and most unsuccessful of these challenges was that of Keill, of whose former appearance in this controversy we have already had so much more reason to commend the zeal than the discretion. Among the problems in the mixed mathematics which had excited most attention, and which seemed best calculated to exercise the resources of the new analysis, was the determination of the path of a projectile in a medium which resists proportionally to the square of the velocity, that being nearly the law of the resistance which the air opposes to bodies moving with great velocity. The resistance of fluids had been treated of by Newton in the second book of the *Principia*, and he had investigated a great number of curious and important propositions relative to its effects. He had considered some of the simpler laws of resistance; but of the case just mentioned he had given no solution, and, after approaching as near as possible to it on all sides, had withdrawn without making an attack. A problem so formidable was not likely to meet with many who, even in the more improved state at which the calculus had now arrived, could hope to overcome its difficulties. Whether Keill had flattered himself that he could resolve the problem, or had forgotten, that when a man proposes a question of defiance to another, he ought to be sure that he can answer it himself, may be doubted; but this is certain, that, without the necessary preparation, he boldly challenged Bernoulli to produce a solution.

Bernoulli resolved the question in a very short time, not only for a resistance proportional to the square, but to any power whatsoever of the velocity; and by the conditions which he affixed to the publication of his solution, took care to expose the weakness of his antagonist. He repeatedly offered to send his solution to a confidential person in London, providing Keill would do the same. Keill never made any reply to a proposal so fair, that there could only be one reason for declining it. Bernoulli, of course, exulted over him cruelly, breaking out in a torrent of vulgar abuse, and losing sight of every maxim of candour and good taste.

Such, then, were the circumstances under which the infinitesimal analysis,—the greatest discovery ever made in the mathematical sciences,—was ushered into the world. Everywhere, as it became known, it enlarged the views, roused the activity, and increased the power of the geometer, while it directed the warmest sentiments of his gratitude and admiration toward the great inventors. In one respect only its effects were different from those which one would have wished to see produced. It excited jealousy between two great men who ought to have been the friends of one another, and disturbed in both that philosophical tranquillity of mind, for the loss of which even glory itself is scarcely an adequate recompense.

In order to form a correct estimate of the magnitude and value of this discovery, it may be useful to look back at the steps by which the mathematical sciences had been prepared for it. When we attempt to trace those steps to their origin, we find the principle of the infinitesimal analysis making its first appearance in the method of exhaustions, as exemplified in the writings of Euclid and Archimedes. These geometers observed, and, for what we know, were the first to observe, that the approach which a rectilineal figure may make to one that is curvilineal, by the increase of the number of its sides, the diminution of their magnitude, and a certain enlargement of the angles they contain, may be such that the properties of the former shall coincide so nearly with those of the latter, that no real difference can be supposed between them without involving a contradiction; and it was in ascertaining the conditions of this approach, and in showing the contradiction to be unavoidable, that the method of exhaustions consisted. The demonstrations were strictly geometrical, but they were often complicated, always indirect, and of course synthetical, so that they did not explain the means by which they had been discovered.

At the distance of more than two thousand years, Cavalieri advanced a step farther, and, by the sacrifice of some apparent, though of no real accuracy, explained, in the method of indivisibles, a principle which could easily be made to assume the more rigid form of exhaustions. This was a very important discovery: though the process was not analytical, the demonstrations were direct, and, when applied to the same subjects, led to the same conclusions which the ancient geometers had deduced. By an indirect proof also, such as those geometers had adopted, it could always be shown that an absurdity followed from supposing the results deduced from the method of indivisibles to be other than rigorously true.

The method of Cavalieri was improved and extended by a number of geometers of great genius who followed him; Torricelli, Roberval, Fermat, Huygens, Barrow, who all observed the great advantage that arose from applying the general theorems concerning variable quantity to the cases where the quantities approached to one another infinitely near, that is, nearer than within any assigned difference. There was, however, as yet, no calculus adapted to these researches, that is, no general method of reasoning by help of arbitrary symbols.

But we must go back a step in point of time, if we would trace accurately the history of this last improvement. Descartes, as has been shown in the former part of this outline, made a great revolution in the mathematical sciences, by applying algebra to the geometry of curves; or, more generally, by applying it to express the relations of variable quantity. This added infinitely to the value of the algebraic analysis, and to the extent of its investigations. The same great mathematician had observed the advantage that would be gained in the geometry of curves, by considering the variable quantities in one state of an equation as differing infinitely little from the corresponding quantities in another state of the same equation. By means grounded on this he had attempted to draw tangents to curves, and to determine their curvature; but it is seldom the destination of nature that a new discovery should be begun and perfected by the same individual; and, in these attempts, though Descartes did not entirely fail, he cannot be considered as having been successful.[1]

At last came the two discoverers, Newton and Leibnitz, who completely lifted up the veil which their predecessors had been endeavouring to draw aside. They plainly saw, as Descartes indeed had done in part, that the infinitely small variations of the ordinate and absciss are closely connected with many properties of the curve, which have but a very remote dependence on the ordinates and abscissæ themselves. Hence they inferred, that to obtain an equation expressing the relations of these variations to one another, was to possess the most direct access to the knowledge of those properties. They observed also, that when an equation of this kind was deduced from the general equation, it admitted of being brought to great simplicity, and of being resolved much more readily than the other. In effect, it assumed the form of a simple equation; but, in order to make this deduction in the readiest and most distinct way, the introduction of new symbols, or of a new algorithm, was necessary, the invention of which could cost but little to the creative genius of the men of whom I now speak. They appear, as has been already shown, to have made their discoveries separately;—Newton first,—Leibnitz afterwards, at a considerable interval, yet the earliest, by several years, in communicating his discoveries to the world.

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[1] Dissertation Fourth, Part i. p. 560.

Thus, though there had been for ages a gradual approach to the new analysis, there were in that progress some great and sudden advances which elevated those who made them to a much higher level than their predecessors. A great number of individuals co-operated in the work; but those who seem essential, and in the direct line of advancement, are Euclid, Cavalieri, Descartes, Newton, and Leibnitz. If any of the others had been wanting, the world would have been deprived of many valuable theorems, and many collateral improvements, but not of any general method essential to the completion of the infinitesimal analysis.

The views, however, of this analysis taken by the two inventors were not precisely the same. Leibnitz, considering the differences of the variable quantities as infinitely small, conceived that he might reject the higher powers of those differences without any sensible error; so that none of those powers but the first remained in the differential equation finally obtained. The rejection, however, of the higher powers of the differentials was liable to objection, for it had the appearance of being only an approximation, and did not come up to the perfect measure of geometrical precision. The analysis, thus constituted, necessarily divided itself into two problems: the first is,—having given an equation involving two or more variable quantities, to find the equation expressing the relation of the differentials, or infinitely small variations of those quantities: the second is the converse of this;—having given an equation involving two or more variable quantities, and their differentials, to exterminate the differentials, and so to exhibit the variable quantities in a finite state. This last process is called *integration* in the language of the differential analysis, and the finite equation obtained is called the *integral* of the given differential equation.

Newton proceeded in some respects differently, and so as to preserve his calculus from the imputation of neglecting or throwing away any thing merely because it was small. Instead of the actual increments of the flowing or variable quantities, he introduced what he called the fluxions of those quantities,—meaning, by fluxions, quantities which had to one another the same ratio which the increments had in their ultimate or evanescent state. He did not reject quantities, therefore, merely because they were so small that he *might* do so without committing any sensible error, but because he *must* reject them, in order to commit no error whatsoever. Fluxions were, with him, nothing else than measures of the velocities with which variable or flowing quantities were supposed to be generated; and they might be of any magnitude, providing they were in the ratio of those velocities, or, which is the same, in the ratio of the nascent or evanescent increments.[1] The fluxions, therefore, and the flowing quantities or fluents of Newton, correspond to the differentials and the sums or integrals of Leibnitz; and though the symbols which denote fluxions are different from those used to express differentials, they answer precisely the same purpose. The fluxionary and differential calculus may therefore be considered as two modifications of one general method, aptly distinguished by the name of the *infinitesimal analysis.*

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[1] "I consider mathematical quantities in this place, not as consisting of small parts, but as described by a continued motion. Lines are described, and thereby generated, not by the apposition of parts, but by the continued motion of points; superficies by the motion of lines," &c. (*Quadrature of Curves*, Introduction.)

By the introduction of this analysis, the domain of the mathematical sciences was incredibly enlarged in every direction. The great improvement which Descartes had made by the application of algebraic equations to define the nature of curve lines was now rendered much more efficient, and carried far beyond its original boundaries. From the equation of the curve the new analysis could deduce the properties of the tangents, and, what was much more difficult, could go back from the properties of the tangents to the equation of the curve. From the same equation it was able to determine the curvature at every point; it could measure the length of any portion of the curve or the area corresponding to it. Nor was it only to algebraic curves that those applications of the calculus extended, but to curves transcendental and mechanical, as in the instances of the catenaria, the cycloid, the elastic curve, and many others. The same sort of research could be applied to curve surfaces described according to any given law, and also to the solids contained by them.

The problems which relate to the *maxima* and *minima*, or the greatest and least values of variable quantities, are among the most interesting in the Mathematics: they are connected with the highest attainments of wisdom and the greatest exertions of power; and seem like so many immovable columns erected in the infinity of space, to mark the eternal boundary which separates the regions of possibility and impossibility from one another. For the solution of these problems, a particular provision seemed to be made in the new geometry.

When any function becomes either the greatest or the least, it does so by the velocity of its increase or of its decrease ceasing entirely, or, in the language of algebra, becoming equal to nothing. But when the velocity with which the function varies becomes nothing, the fluxion which is proportional to that velocity must become nothing also. Therefore, it is only necessary to take the fluxion of the given function, and by supposing it equal to nothing, an equation will be obtained in finite terms, (for the fluxion will entirely disappear) expressing the relation of the quantities when the function assigned is the greatest or the least possible.

Another kind of maximum or minimum, abounding also in interesting problems, is more difficult by far than the preceding, and, when taken generally, seems to be only accessible to the new analysis. Such cases occur when the function of the variable quantities which is to be the greatest or the least is not given, but is itself the thing to be found; as when it is proposed to determine the line by which a heavy body can descend in the least time from one point to another. Here the equation between the co-ordinates of the curve to be found is, of course, unknown, and the function of those coordinates, which denotes the time of descent, cannot therefore be algebraically expressed, so that its fluxion cannot be taken in the ordinary way, and thus put equal to nothing. The former rule, then, is not applicable in such cases, and it is by no means obvious in what manner this difficulty is to be overcome. The general problem exercised the ingenuity of both the Bernoullis, as it has since done of many other mathematicians of the greatest name. As there are in such problems always two conditions, according to the first of which a certain property is to remain constant, or to belong to all the individuals of the species, and, according to the second, another property is to be the greatest or the least possible; and as, in some of the simplest of such questions,[1] the constant quantity is the circumference or perimeter of a certain curve, so problems of this kind have had the name of *Isoperimetrical* given them; a term which has thus come to denote one of the most curious and difficult subjects of mathematical investigation.

The new analysis, especially according to the view taken of it by Newton, is peculiarly adapted to physical researches, as the hypothesis of quantities being generated by continued motion comes there to coincide exactly with the fact. The momentary increments or the fluxions represent so precisely the forces by which the changes in nature are produced, that this doctrine seemed created for the express purpose of penetrating into the interior of things, and taking direct cognizance of those animating powers which, by their subtilty, not only elude the observation of sense, but the ordinary methods of geometrical investigation. The infinitesimal analysis alone affords the means of measuring forces, when each acts separately, and instantaneously under conditions that can be accurately ascertained. In comparing the effects of continued action, the variety of time and circumstance, and the continuance of effects after their causes have ceased, introduce so much uncertainty, that nothing but vague and unsatisfactory conclusions can be deduced. The analysis of infinites goes directly to the point; it measures the intensity or instantaneous effort of the force, and, of course, removes all those causes of uncertainty which prevailed when the results of *continued* action could alone be estimated. It is not even by the effects produced in a short time, but by effects taken in their *nascent* or *evanescent* state, that the true proportion of causes must be ascertained.

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[1] The most simple problem of the kind is strictly and literally *isoperimetrical*, viz. of all curves having the same perimeter, to find that which has the greatest area. Elementary geometry had pronounced this curve to be the circle long before there was any idea of an entire class of problems characterized by similar conditions. *Vide Pappi Alexandrini Collect. Math.* lib. v. prop. 2. &c.

Thus, though the astronomers had proved that the planets describe ellipses round the sun as the common focus, and that the line from the sun to each planet sweeps over areas proportional to the time,—had not the geometer resolved the elliptic motion into its primary elements, and compared them in their state of evanescence, it would never have been discovered that these bodies gravitate to the sun with forces which are inversely as the square of their distances from the centre of that luminary. Thus, fortunately, the first discovery of Newton was the instrument which was to conduct him safely through all the intricacies of his future investigations.

The calculus, as already remarked, necessarily divides itself into two branches; one which, from the variable quantities, finds the relation of their fluxions or differentials; another which, from the relation of these last, investigates the relation of the variable quantities themselves. The first of these problems is always possible, and, in general, easy to be resolved; the second is not always possible, and when possible, is often very difficult, but in various degrees, according to the manner in which the differentials and the variable quantities are combined with one another.

If the function into which the differential stands multiplied consist of a single term, or an aggregate of terms, in each of which the variable quantity is raised to a power expounded by a number positive, negative, or fractional, the integration can be effected with ease, either in algebraic or logarithmic terms; and the calculus had not been long known before this problem was completely resolved.

The second case of this first division is,—when the given function is a fraction having a binomial or multinomial denominator, the terms of which contain any powers whatever of the variable magnitude, but without involving the radical sign. If the denominator contain only the simple power of the variable quantity, the integral is easily found by logarithms; if it be complex, it must be resolved either into simple or quadratic divisors, which, granting the solution of equations, is always possible, at least by approximation, and the given fraction is then found equal to an aggregate of simple fractions, having these divisors for their denominators, and of which the fluents can always be exhibited in algebraic terms, or in terms of logarithms and circular arches. This very general and important problem was resolved by J. Bernoulli as early as the year 1702.

The denominator is in this last case supposed rational; but if it be irrational, the integration requires other means to be employed. Here Leibnitz and Bernoulli both taught how, by substitutions, as in *Diophantine* problems, the irrationality might be removed, and the integration of course reduced to the former case. Newton employed a different method, and, in his *Quadrature of Curves*, found the fluents, by comparing the given fluxion with the formulas immediately derived from the expression of circular or hyperbolic areas. The integrations of these irrational formulæ, whichever of the methods be employed, often admit of being effected with singular elegance and simplicity; but a general integration of all the formulæ of this kind, except by approximation, is not yet within the power of analysis.

The second general division of the problem of integration, viz. when the two variable quantities and their differentials are mixed together on each side of the equation, is a more difficult subject of inquiry than the preceding. It may indeed happen that an equation, which at first presents itself under this aspect, can, by the common rules of algebra, have the quantities so separated, that on each side of the sign of equality there shall be but one variable quantity with its fluxion; and when this is done, the integration is reduced to one of the cases already enumerated.

When such separation cannot be made, the problem is among the most difficult which the infinitesimal analysis presents, at the same time that it is the key to a vast number of interesting questions both in the pure and the mixed mathematics. The two Bernoullis applied themselves strenuously to the elucidation of it; and to them we owe all the best and most accurate methods of resolving such questions which appeared in the early history of the calculus, and which laid the foundation of so many subsequent discoveries. This is a fact which cannot be contested; and it must be acknowledged also, that on the same subject the writings of the English mathematicians were then, as they continue to be at this day, extremely defective. Newton, though he had treated of this branch of the infinitesimal analysis with his usual ingenuity and depth, had done so only in his work on Fluxions, which did not see the light till several years after his death, when, in 1736, it appeared in Colson's Translation. But that work, even had it come into the hands of the public in the author's lifetime, would not have remedied the defect of which I now speak. When the fluxionary equation could not be integrated by the simplest and most elementary rules, Newton had always recourse to approximations by infinite series, in the contrivance of which he indeed displayed great ingenuity and address. But an approximation, let it be ever so good, and converge ever so rapidly, is always inferior to an accurate and complete solution, if this last possess any tolerable degree of simplicity. The series which affords the approximation cannot converge always, or in all states of the variable quantity; and its utility, on that account, is so much limited, that it can hardly lead to any general result. Besides, it does not appear that these series can always be made to involve the arbitrary or indeterminate quantity, without which no fluent can be considered as complete. For these reasons, such approximations should never be resorted to till every expedient has been used to find an accurate solution. To this rule, however, Newton's method does not conform, but employs approximation in cases where the complete integral can be obtained. The tendency of that method, therefore, however great its merit in other respects, was to give a direction to research which was not always the best, and which, in many instances, made it fall entirely short of the object it ought to have attained. It is true that many fluxionary equations cannot be integrated in any other way; but by having recourse to it indiscriminately, we overlook the cases in which the integral can be exactly assigned. Accordingly, Bernoulli, by following a different process, remarked entire classes of fluxionary or differential equations, that admitted of accurate integration. Thus he found, that differential equations, if homogeneous,[1] however complicated, may always have the variable quantities separated, so as to come under one of the simpler forms already enumerated. By the introduction, also, of exponential equations, which had been considered in England as of little use, he materially improved this branch of the calculus.

To all these branches of analysis we have still another to add of indefinite extent, arising out of the consideration of the fluxions or differentials of the higher orders, each of these orders being deduced from the preceding, just as first fluxions are from the variable quantities to which they belong. To understand this, conceive the successive values of the first fluxions of any variable quantity to constitute a new series of variable quantities flowing with velocities, the measures of which form the fluxions of the second order, from which, in the same manner, are deduced fluxions of the third and of still higher orders. The general principles are the same as in the fluxions of the first order, but the difficulties of the calculus are greater, particularly in the integrations; for, to rise from second fluxions to the variable quantities themselves, two integrations are necessary; from third fluxions, three; and so on.

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[1] Homogeneous equations, in the differential calculus, are those in which the sum of the exponents of the variable quantities is the same in all the terms.

The tract which first made known the new analysis was that of Leibnitz, published, as already remarked, in the first volume of the *Acta Eruditorum* for 1684, where it occupies no more than six pages,[1] and is the work of an author not yet become very familiar with the nature of his own invention. It was sufficient, however, to explain that invention to mathematicians; but, nevertheless, some years elapsed before it drew much attention. The Bernoullis were the first who perceived its value, and made themselves masters of the principles and methods contained, or rather suggested, in it. Leibnitz published many other papers in the *Acta Eruditorum* and the journals of the times, full of original views and important hints, thrown out very briefly, and requiring the elucidations which his friends just mentioned were always so willing and so able to supply. The number of literary and scientific objects which divided the attention of the author himself was so great, that he had not time to bestow on the illustration and development of the most important of his own discoveries; and the new analysis, for all that he has taught, would have been very little known, and very imperfectly unfolded, if the two excellent geometers just named had not come to his assistance. Their tracts were also, like his, scattered in the different periodic works of that time; and several years elapsed before any elementary treatise explained the general methods, and illustrated them by examples. The first book in which this was done, so far at least as concerned the differential or direct calculus, was the *Analyse des infiniment Petits* of the Marquis de l'Hopital, published in 1696; a work of great merit, which did much to diffuse the knowledge of the new analysis. It was well received at that time, and has maintained its character to the present day. The author, a man of genius, indefatigable and ardent in the pursuits of science, had enjoyed the *viva voce* instructions of John Bernoulli, on the subject of the new geometry, and therefore came forward with every possible advantage.

It was long after this before the works of the Bernoullis were collected together, those of James in two quarto volumes, and of John in four.[2] In the third of these last volumes is a tract of considerable length, with the title of *Lectiones de Methodo Integralium*, written in 1691 and 1692, for the use of M. de l'Hopital, to whose book on the Differential Calculus it seems to have been intended as a sequel. It is a work of great merit; and affords a distinct view of many of the most general methods of integration, with their application to the most interesting problems; so that, though the earliest treatise on that subject, it remains at this day one of the best compends of the new analysis of which the mathematical world is in possession. Indeed the whole of the volumes just referred to are highly interesting, as containing the original germs of the new analysis, and as being the work of men always inspired by genius, sometimes warmed by opposition, and generally animated by the success which accompanied their researches.

But we must now look at the original works of the earliest inventor. Newton, besides his letters published in the *Commercium Epistolicum*, is the author of three tracts on the new analysis that have all been occasionally mentioned. None of them, however, appeared nearly so soon as a great number of the pieces which have just been enumerated. The *Quadrature of Curves*, written as early as 1665 or 1666, did not appear till 1704; and though it be a treatise of great value, and containing very important and very general theorems concerning the quadrature of curves, it must be allowed that it is not well adapted to make known the spirit and the views of the infinitesimal analysis. After a short introduction, which is indeed analytical, and which explains the idea of a fluxion with great brevity and clearness, the treatise sets out with proposing to find any number of curves that can be squared; and here the demonstrations become all synthetical, without any thing that may be properly called analytical investigation. By synthetical demonstrations I do not mean reasonings where the algebraic language is not used, but reasonings, whatever language be employed, where the solution of the proposed question is first laid down, and afterwards demonstrated to be true. Such is the method pursued throughout this work; and it is wonderful how many valuable conclusions concerning the areas of curves, and their reduction to the areas of the circle and hyperbola, are in that manner deduced. But though truths can be very well conveyed in the synthetical way, the methods of investigating truth are not communicated by it, nor the powers of invention directed to their proper objects. As an elementary treatise on the new analysis, the *Quadrature of Curves* is therefore imperfect, and not calculated, without great study, to give to others any portion of the power which the author himself has exerted. The problem of finding fluents, though it be that on which the whole quadrature of curves depends, is entirely kept out of view, and never once proposed in the course of a work which, at the same time, is full of the most elaborate and profound reasonings.

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[1] *Nova Methodus pro Maximis et Minimis*, &c.: LEIBNITII *Opera*, tom. III. p. 167.

[2] Those of James were published at Geneva in 1744; of John, at Lausanne and Geneva in 1742.

Newton had a great fondness for the synthetical method, which is apparent even in the most analytical of his works. In his *Fluxions*, when he is treating of the quadrature of curves, he says, "After the area of a curve has been found and constructed, we should consider about the demonstration of the construction, that, laying aside all algebraical calculation as much as may be, the theorem may be adorned and made elegant, so as to become fit for public view."[1] This is followed by two or three examples, in which the rule here given is very happily illustrated. When the analysis of a problem requires, like the quadrature of curves, the use of the inverse method of fluxions, the reversion of that analysis, or the synthetical demonstration, must proceed by the direct method, and therefore may admit of more simplicity than the others, so as, in the language of the above passage, to be easily adorned and made elegant.

The book of *Fluxions* is, however, an excellent work, entering very deeply into the nature and spirit of the calculus,—illustrating its application by well-chosen examples,—and only failing, as already said, by having recourse, for finding the fluents of fluxionary equations, too exclusively to the method of series, without treating of the cases in which exact solutions can be obtained.

Of the works that appeared in the early stages of the calculus, none is more entitled to notice than the *Harmonia Mensurarum* of Cotes. The idea of reducing the areas of curves to those of the circle and hyperbola, in those cases which did not admit of an accurate comparison with rectilineal spaces, had early occurred to Newton, and was very fully exemplified in his *Quadrature of Curves.* Cotes extended this method:—his work appeared in 1722, and gave the rules for finding the fluents of fractional expressions, whether rational or irrational, greatly generalized and highly improved by means of a property of the circle discovered by himself, and justly reckoned among the most remarkable propositions in geometry. It is singular that a work so profound and so useful as the *Harmonia Mensurarum* should never have acquired, even among the mathematicians of England, the popularity which it deserves; and that, on the Continent, it should be very little known, even after the excellent commentary and additions of Bishop Walmesley. The reasons perhaps are, that, in many parts, the work is obscure; that it does not explain the analysis which must have led to the *formulæ* contained in the tables; and that it employs an unusual language and notation, which, though calculated to keep in view the analogy between circular and hyperbolic areas, or between the measures of angles and of ratios, do not so readily accommodate themselves to the business of calculation as those which are commonly in use. Demoivre, a very skilful and able mathematician, improved the method of Cotes, and explained many things in a manner much more clear and analytical than had hitherto been done.[1]

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[1] NEWTON'S *Fluxions*, Colson's Translation, p. 116, sect. 107.

Another very original and profound writer of this period was Brook Taylor, who has already been often mentioned, and who, in his *Method of Increments*, published in 1715, added a new branch to the analysis of variable quantity. According to this method, quantities are supposed to change, not by infinitely small, but by finite increments, or such as may be of any magnitude whatever. There are here, therefore, as in the case of fluxions or differentials, two general questions: A function of a variable quantity being given, to find the expression for the finite increment of that function, the increment of the variable quantity itself being a finite magnitude. This corresponds to the direct method of fluxions; the other question corresponds to the inverse, viz. A function being given containing variable quantities, and their increments any way combined, to find the function from which it is derived. The author has considered both these problems, and in the solution of the second, particularly, has displayed much address. He has also made many ingenious applications of this calculus, both to geometrical and physical questions, and, above all, to the summation of series,—a problem for the solution of which it is peculiarly adapted.

Taylor, however, was more remarkable for the ingenuity and depth, than for the perspicuity of his writings. Even a treatise on *Perspective*, of which he is the author, though in other respects excellent, has always been complained of as obscure; and it is no wonder if, on a new subject, and one belonging to the higher geometry, his writings should be still more exposed to that reproach. This fault was removed, and the whole theory explained with great clearness, by M. Nicole, of the Academy of Sciences of Paris, in a series of *Mémoires* from the year 1717 to 1727.

A single analytical formula in the *Method of Increments* has conferred a celebrity on its author, which the most voluminous works have not often been able to bestow. It is known by the name of Taylor's Theorem, and expresses the value of any function of a variable quantity in terms of the successive orders of increments, whether finite or infinitely small. If any one proposition can be said to comprehend in it a whole science, it is this: for from it almost every truth and every method of the new analysis may be deduced. It is difficult to say whether the theorem does most credit to the genius of the author, or the power of the language which is capable of concentrating such a vast body of knowledge in a single expression. Without an acquaintance with algebra, it is impossible, I believe, to conceive the manner in which this effect is produced.

By means of its own intrinsic merit, and the advantageous display of it made in the works now enumerated, the new analysis, long before the expiration of the period of which I am here treating, was firmly established all over Europe. It did not, however, exist everywhere in the same condition, nor under the same form; with the British and Continental mathematicians, it was referred to different origins; it was in different states of advancement; the notation and some of the fundamental ideas were also different. The authors communicated little with one another, except in the way of defiance or reproach; and, from the angry or polemical tone which their speculations often assumed, one could hardly suppose that they were pursuing science in one of its most abstract and incorporeal forms.

Though the algorithm employed, and the books consulted on the new analysis, were different, the mathematicians of Britain and of the Continent had kept pace very nearly with one another during the period now treated of, except in one branch, the integration of differential or of fluxional equations. In this, our countrymen had fallen considerably behind, as has been already explained; and the distance between them and their brethren on the Continent continued to increase, just in proportion to the number and importance of the questions, physical and mathematical, which were found to depend on these integrations. The habit of studying only our own authors on these subjects, produced at first by our admiration of Newton and our dislike to his rivals, and increased by a circumstance very insignificant in itself, the diversity of notation, prevented us from partaking in the pursuits of our neighbours, and cut us off in a great measure from the vast field in which the genius of France, of Germany, and Italy, was exercised with so much activity and success. Other causes may have united in the production of an effect which the mathematicians of this country have had much reason to regret; but the evil had its origin in the spirit of jealousy and opposition, which arose from the controversies that have just passed under our review. The habits so produced continued long after the spirit itself had subsided.

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[1] DEMOIVRE, *Miscellanea Analytica*. See also the work of an anonymous author, *Epistola ad Amicum de Cotesii Inventis*.

It must not be supposed that so great a revolution in science as that which was made by the introduction of the new analysis could be brought about entirely without opposition, as in every society there are some who think themselves interested to maintain things in the condition wherein they have found them. The considerations are indeed sufficiently obvious, which, in the moral and political world, tend to produce this effect, and to give a stability to human institutions, often so little proportionate to their real value or to their general utility. Even in matters purely intellectual, and in which the abstract truths of arithmetic and geometry seem alone concerned, the prejudices, the selfishness, or vanity of those who pursue them, not unfrequently combine to resist improvement, and often engage no inconsiderable degree of talent in drawing back, instead of pushing forward, the machine of science. The introduction of methods entirely new must often change the relative place of the men engaged in scientific pursuits; and must oblige many, after descending from the stations they formerly occupied, to take a lower position in the scale of intellectual advancement. The enmity of such men, if they be not animated by a spirit of real candour and the love of truth, is likely to be directed against methods by which their vanity is mortified, and their importance lessened. Though such changes as this must have everywhere accompanied the ascendency acquired by the calculus, for the credit of mathematicians it must be observed, that no one of any considerable eminence has had the misfortune to enrol his name among the adversaries of the new science; and that Huygens, the most distinguished and most profound of the older mathematicians then living, was one of the most forward to acknowledge the excellence of that science, and to make himself master of its rules, and of their application.

Nevertheless, certain adversaries arose successively in Germany, France, and England, the countries in which the new methods first became known.

Nieuwentyt, an author commendable as a naturalist, and as a writer on morals, but a very superficial geometer, aimed the first blow at the Differential Calculus. He objected to the explanation of Leibnitz, and to the notion of quantities infinitely small.[1] It seemed as if he were unwilling to believe in the reality of objects smaller than those discovered by his own microscope, and were jealous of any one who should come nearer to the limit of extension than he himself had done. Leibnitz thought his objections not undeserving of a reply; but the reply was not altogether satisfactory. A second was given with better success; and afterwards Hermann and Bernoulli each severally defeated an adversary, who was but very ill able to contend with either of them.

Soon after this, the calculus had to sustain an attack from two French academicians, which drew more attention than that of the Dutch naturalist. One of these, Rolle, was a mathematician of no inconsiderable acquirement, but whose chief gratification consisted in finding out faults in the works of others. He founded his objections to the differential calculus, not on the score of principles or of general methods, but on certain cases which he had sought out with great industry, in which those methods seemed to him to lead to false and contradictory conclusions. On examination, however, it turned out, that in every one of those instances the error was entirely his own; that he had misapplied the rules; and that his eagerness to discover faults had led him to commit them. His errors were detected and pointed out with demonstrative evidence by Varignon, Saurin, and some others, who were among the first to perceive the excellence and to defend the solidity of the new geometry. These disputes were of consequence enough to occupy the attention of the Academy of Sciences during a great part of the year 1701.

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[1] He published *Analysis Infinitorum* at Amsterdam, in 1695; and another tract, *Considerationes circa Calculi Differentialis Principia*, in the year following. This last was answered by Hermann.

The Abbé Gallois joined with Rolle in his hostility to the calculus; and though he added very little to the force of the attack, he kept the field after the other had retired from the combat. Fontenelle, in his *Eloge* on the Abbé, has given an elegant turn to the apology he makes for him. "His taste for antiquity made him suspicious of the geometry of infinites. He was, in general, no friend to any thing that was new, and was always prepared with a kind of *ostracism* to put down whatever appeared too conspicuous for a free state like that of letters. The geometry of infinites had both these faults, and particularly the latter."

After all these disputes were quieted in France, and the new analysis appeared completely victorious, it had an attack to sustain in England from a more formidable quarter. Berkeley, bishop of Cloyne, was a man of first-rate talents, distinguished as a metaphysician, a philosopher, and a divine. His geometrical knowledge, however, which, for an attack on the method of fluxions, was more essential than all his other accomplishments, seems to have been little more than elementary. The motive which induced him to enter on discussions so remotely connected with his usual pursuits, has been variously represented; but, whatever it was, it gave rise to the *Analyst*, in which the author professes to demonstrate, that the new analysis is inaccurate in its principles, and that if it ever lead to true conclusions, it is from an accidental compensation of errors that cannot be supposed always to take place. The argument is ingeniously and plausibly conducted, and the author sometimes attempts ridicule with better success than could be expected from the subject: thus, when he calls ultimate ratios the *ghosts of departed quantities*, it is not easy to conceive a witty saying more happily fastened on a mere mathematical abstraction.

The *Analyst* was answered by Jurin, under the signature of *Philalethes;* and to this Berkeley replied in a tract entitled *A Defence of Free-thinking in Mathematics.* Replies were again made to this; so that the argument assumed the form of a regular controversy; in which, though the defenders of the calculus had the advantage, it must be acknowledged that they did not always argue the matter quite fairly, nor exactly meet the reasoning of their adversary. The true answer to Berkeley was, that what he conceived to be an accidental compensation of errors was not at all accidental, but that the two sets of quantities that seemed to him neglected in the reasoning were in all cases necessarily equal, and an exact balance for one another. The Newtonian idea of a fluxion contained in it this truth, and so it was argued by Jurin and others, but not in a manner so logical and satisfactory as might have been expected. Perhaps it is not too much to assert, that this was not completely done till Lagrange's *Theory of Functions* appeared. Thus, if the author of the *Analyst* has had the misfortune to enrol his name on the side of error, he has also had the credit of proposing difficulties of which the complete solution is only to be derived from the highest improvements of the calculus.

This controversy made some noise in England, but I do not think that it ever drew much attention on the Continent. The *Analyst*, I imagine, notwithstanding its acuteness, never crossed the Channel. Montucla evidently knows it only by report, and seems as little acquainted with the work as with its author, of whom he speaks very slightly, and supposes he has sufficiently described him by saying, that he has written a book against the existence of matter, and another in praise of tar-water. But it is less from the opinions which men support than from the manner in which they support them, that their talents are to be estimated. If we judge by this criterion, we shall pronounce Berkeley to be a man of genius, whether he be employed in attacking the infinitesimal analysis, in disproving the existence of the external world, or in celebrating the virtues of tar-water.[1]

SECTION II.

MECHANICS, GENERAL PHYSICS, &c.

The discoveries of Galileo, Descartes, and other mathematicians of the seventeenth century, had made known some of the most general and important laws which regulate the phenomena of moving bodies. The inertia, or the tendency of body, when left to itself, to preserve unchanged its condition either of motion or of rest; the effect of an impulse communicated to a body, or of two simultaneous impulses, had been carefully examined, and had led to the discovery of the composition of motion. The law of equilibrium, not in the lever alone, but in all the mechanical powers, had been determined; and the equality of action to re-action, or of the motion lost to the motion acquired, had not only been established by reasoning, but confirmed by experiment. The fuller elucidation and further extension of these principles were reserved for the period now treated of.

The development of truth is often so gradual, that it is impossible to assign the time when certain principles have been first introduced into science. Thus, the principle of *virtual velocities*, as it is termed, which is now recognised as regulating the equilibrium of all machines whatsoever, was perceived to hold in particular cases, long before its full extent or its perfect universality was understood. Galileo made a great step toward the establishment of this principle when he generalized the property of the lever, and showed, that an equilibrium takes place whenever the sums of the opposite momenta are equal, meaning by momentum the product of the force into the velocity of the point at which it is applied. This was carried farther by Wallis, who appears to have been the first writer who, in his *Mechanica*, published in 1669, founded an entire system of statics on the principle of Galileo, or the equality of the opposite momenta. The proposition, however, was first enunciated in its full generality, and with perfect precision,[2] by John Bernoulli, in a letter to Varignon, so late as the year 1717. Varignon inserted this letter at the end of the second edition of his *Projet d'une Nouvelle Mé-*

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[1] Though Berkeley reasons very plausibly, and with considerable address, he hurts his cause by the comparison so often introduced between the mysteries of religion and what he accounts the mysteries of the new geometry. From this it is natural to infer, that the author is avenging the cause of religion on the infidel mathematician to whom his treatise is addressed; and an argument that is suspected to have any other object than that at which it is directly aimed, must always lose somewhat of its weight.

The dispute here mentioned did not take place till about the year 1734; so that I have here treated of it by anticipation, being unwilling to resume the subject of controversies which, though perhaps useful at first for the purpose of securing the foundations of science, are long since set to rest, and never likely to be revived.

[2] The principle of virtual velocities may be thus enunciated: If a system of bodies be in a state of equilibrium, in consequence of the action of any forces whatever on certain points in the system; then, supposing the equilibrium to be for a moment destroyed, the small space moved over by each of these points will express the virtual velocity of the power applied to it; and if each force be multiplied into its virtual velocity, the sum of all the products where the velocities are in the same direction, will be equal to the sum of all those in which they are in the opposite.

The distinction between actual and virtual velocities was first made by Bernoulli, and is very essential to thinking as well as to speaking with accuracy on the nature of equilibriums.

canique, which was not published till 1725. The first edition of the same book appeared in 1687, and had the merit of deriving the whole theory of the equilibrium of the mechanical powers from the single principle of the composition of forces. At first sight, there appear in mechanics two independent principles of equilibrium; that of the lever, or of equal and opposite momenta, and that of the composition of forces. To show that these coincide, and that the one may be deduced from the other, is, therefore, doing a service to science; and this the ingenious author just named accomplished by help of a property of the parallelogram, which he seems to have been the first who demonstrated.

The *Principia Mathematica* of Newton, published also in 1687, marks a great era in the history of human knowledge, and had the merit of effecting an almost entire revolution in mechanics, by giving new powers and a new direction to its researches. In that work the composition of forces was treated independently of the composition of motion, and the equilibrium of the lever was deduced from the former, as well as in the treatise already mentioned. From the equality of action and re-action it was also inferred, that the state of the centre of gravity of any system of bodies is not changed by the action of those bodies on one another. This is a great proposition in the mechanics of the universe, and is one of the steps by which that science ascends from the earth to the heavens; for it proves that the quantity of motion existing in nature, when estimated in any one given direction, continues always of the same amount.

But the new applications of mechanical reasoning,—the reduction of questions concerning force and motion to questions of pure geometry, and the mensuration of mechanical action by its nascent effects,—are what constitute the great glory of the *Principia*, considered as a treatise on the theory of motion. A transition was there made from the consideration of forces acting at stated intervals, to that of forces acting continually,—and from forces constant in quantity and direction to those that converge to a point, and vary as any function of the distance from that point; the proportionality of the areas described about the centre of force, to the times of their description; the equality of the velocities generated in descending through the same distance by whatever route; the relation between the squares of the velocities produced or extinguished; and the sum of the accelerating or retarding forces, computed with a reference, not to the time during which, but to the distance over which they have acted. These are a few of the mechanical and dynamical discoveries contained in the same immortal work; a fuller account of which belongs to the history of physical astronomy.

The end of the seventeenth and the beginning of the eighteenth centuries were rendered illustrious, as we have already seen, by the mathematical discoveries of two of the greatest men who have ever enlightened the world. A slight sketch of the improvements which the theory of mechanics owes to Newton has been just given; those which it owes to Leibnitz, though not equally important, nor equally numerous, are far too conspicuous to be passed over in silence. So far as concerns general principles, they are reduced to three; the argument of the sufficient reason, the law of continuity, and the measurement of the force of moving bodies by the square of their velocities; which last being a proposition that is true or false according to the light in which it is viewed, I have supposed it placed in that which is most favourable.

With regard to the first of these, *the principle of the sufficient reason*, according to which, nothing exists in any state without a reason determining it to be in that state rather than in any other,—though it be true that this proposition was first distinctly and generally announced by the philosopher just named, yet is it certain that, long before his time, it had been employed by others in laying the foundations of science. Archimedes and Galileo had both made use of it; and perhaps there never was any attempt to place the elementary truths of science on a solid foundation, in which this principle had not been employed. We have an example of its application in the proof usually given, that a body in motion cannot change the direction of its motion, abstraction being made from all other bodies, and from all external action; for it is evident, that no reason exists to determine the change of motion to be in one direction more than another, and we therefore conclude that no such change can possibly take place. Many other instances might be produced where the same principle appears as an axiom of the clearest and most undeniable evidence. Wherever, indeed, we can pronounce with certainty that the conditions which determine two different things, whether magnitudes or events, are in two cases precisely the same, it cannot be doubted that these events or magnitudes are in all respects identical.

However sound this principle may be in itself, the use which Leibnitz sometimes made of it has tended to bring it into discredit. He argued, for example, that of the particles of matter no two can possess exactly the same properties, or can perfectly resemble one another, otherwise the Supreme Being could have no reason for employing one of them in a particular position more than another, so that both must necessarily be rejected. To argue thus, is to suppose that we completely understand the manner in which motives act on the mind of the Divinity;[1] a postulate that seems but ill suited to the limited sphere of the human understanding. But, if Leibnitz has misapplied his own principle, and extended its authority too far, this affords no ground for rejecting it when we are studying the ordinary course of nature, and arguing about the subjects of experiment and observation. In fact, therefore, the sciences which aspire to place their foundation on the solid basis of necessary truth, are much indebted to Leibnitz for the introduction of this principle into philosophy.

Another principle of great use in investigating the laws of motion, and of change in general, was brought into view by the same author, —*the law of continuity*,—according to which, nothing passes from one state to another without passing through all the intermediate states. Leibnitz considers himself as the first who made known this law; but it is fair to remark, that, in as much as motion is concerned, it was distinctly laid down by Galileo,[2] and ascribed by him to Plato. But, though Leibnitz was not the first to discover the law of continuity, he was the first who regarded it as a principle in philosophy, and used it for trying the consistency of theories, or of supposed laws of nature, and the agreement of their parts with one another. It was in this way that he detected the error of Descartes's conclusions concerning the collision of bodies, showing, that though one case of collision must necessarily graduate into another, the conclusions of that philosopher did by no means pass from one to another by such gradual transition. Indeed, for the purpose of such detections, the knowledge of this law is extremely useful; and I believe few have been much occupied in the investigations either of the pure or mixed mathematics, who have not often been glad to try their own conclusions by the test which it furnishes.

Leibnitz considered this principle as known *a priori;* because if any *saltus* were to take place, that is, if any change were to happen without the intervention of time, the thing changed must be in two different conditions at the same individual instant, which is obviously impossible. Whether this reasoning be quite satisfactory or not, the conformity of the law to the facts generally observed, cannot but entitle it to great authority in judging of the explanations and theories of natural phenomena.

It was the usual error, however, of Leibnitz and his followers, to push the metaphysical principles of science into extreme cases, where they lead to conclusions to which it was hardly possible to assent. The Academy of Sciences at Paris having proposed as a prize question the Investigation of the Laws of the Communication of Motion,[3] John Bernoulli presented an Essay on the subject, very ingenious and profound; in which, however, he denied the existence of hard bodies, because, in the collision of such bodies, a finite change of motion must take place in an instant; an event which, on the principle just explained, he maintained to be impossible. Though the Essay was admired, this conclusion was objected to; and D'Alembert, in his *Eloge* on the author, remarks, that, even in the collision of elastic bodies, it is difficult to conceive how, among the parts which first come into contact, a sudden change, or a change *per saltum*, can be avoided. Indeed it can only be avoided by supposing that there is no real contact, and that bodies begin to act upon one another when their surfaces, or what seems to be their surfaces, are yet at a distance.

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[1] The argument of Leibnitz seems evidently inconclusive. For, though there were two similar and equal atoms, yet as they could not co-exist in the same space, they would not, so far as position is concerned, bear the same relation to the particles that surrounded them: there might exist, therefore, considering them as part of the materials to be employed in the construction of the universe, very good reasons for assigning different situations to each.

[2] *Opere di Galileo*, tom. III. p. 150, and tom. II. p. 32. edit. Padova, 1744.

[3] In 1724.

Maclaurin and some others are disposed, on account of the argument of Bernoulli, to reject the law of continuity altogether. This, however, I cannot help thinking, is to deprive ourselves of an auxiliary that, under certain restrictions, may be very useful in our researches, and is often so, even to those who profess to reject its assistance. It is admitted that the law of continuity generally leads right; and if it sometimes lead wrong, the true business of philosophy is to define when it may be trusted to as a safe guide, and what, on the other hand, are the circumstances which render its indications uncertain.

The discourse of Bernoulli, just referred to, brought another new conclusion into the field, and began a controversy among the mathematicians of Europe, which lasted for many years. It was a new thing to see geometers contending about the truths of their own science, and opposing one demonstration to another. The spectacle must have given pain to the true philosopher, but may have afforded consolation to many who had looked with envy on the certainty and quiet prevailing in a region from which they found themselves excluded.

Descartes had estimated the force of a moving body by the quantity of its motion, or by the product of its velocity into its mass. The mathematicians and philosophers who followed him did the same, and the product of these quantities was the measure of force universally adopted. No one indeed had ever thought of questioning the conformity of this measure to the phenomena of nature, when, in 1686, Leibnitz announced in the Leipsic *Journal* the *demonstration of a great error committed by Descartes and others, in estimating the force of moving bodies.* In this paper the author endeavoured to show, that the force of a moving body is not proportional to its velocity simply, but to the square of its velocity; and he supported this new doctrine by very plausible reasoning. A body, he says, projected upward against gravity, with a double velocity, ascends to four times the height; with the triple velocity, to nine times the height; and so on, the height ascended to being always as the square of the velocity. But the height ascended to is the effect, and is the natural measure of the force; therefore the force of a moving body is as the square of its velocity. Such was the first reasoning of Leibnitz on this subject,—simple, and apparently conclusive; nor should it be forgotten that, during the long period to which the dispute was lengthened out, and notwithstanding the various shapes which it assumed, the reasonings on his side were nothing more than this original argument, changed in its form, or rendered more complex by the combination of new circumstances, so as to be more bewildering to the imagination, and more difficult either to apprehend or to refute.[1]

John Bernoulli was at first of a different opinion from his friend and master, but came at length to adopt the same; which, however, appears to have gone no farther till the discourse was submitted to the Academy of Sciences, as has been already mentioned. The mathematical world could not look with indifference on a question which seemed to affect the vitals of mechanical science, and soon separated into two parties, in the arrangement of which, however, the effects of national predilection might easily be discovered. Germany, Holland, and Italy, declared for the *vis viva;* England stood firm for the old doctrine; and France was divided between the two opinions. No controversy, perhaps, was ever carried on by more illustrious disputants: Maclaurin, Stirling, Desaguliers, Jurin, Clarke, Mairan, were engaged on the one side; on the opposite were Bernoulli, Hermann, Poleni, S'Gravesande, Muschenbroeck; and it was not till long after the period to which this part of the Dissertation is confined, that the debate could be said to be brought to a conclusion. That I may not, however, be obliged to break off a subject of which the parts are closely connected together, I shall take the liberty of transgressing the limits which the consideration of time would prescribe, and of now stating, as far as my plan admits of it, all that respects this celebrated controversy.

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[1] To mere pressure Leibnitz gave the name of *vis mortua.* and to the force of moving bodies the name of *vis viva.* The former he admitted to be proportional to the simple power of the *virtual* velocity, and the second he held to be proportional to the square of the *actual* velocity.

A singular circumstance may be remarked in the whole of the dispute. The two parties who adopted such different measures of force, when any mechanical problem was proposed concerning the action of bodies, whether at rest or in motion, resolved it in the same manner, and arrived exactly at the same conclusions. It was therefore evident, that, however much their language and words were opposed, their ideas or opinions exactly agreed. In reality, the two parties were not at issue on the question; their positions, though seemingly opposite, were not contrary to one another; and after debating for nearly thirty years, they found out this to be the truth. That the first men in the scientific world should have disputed so long with one another, without discovering that their opposition was only in words,—and that this should have happened, not in any of the obscure and tortuous tracks through which the human mind must grope its way in anxiety and doubt, but in one of the clearest and straightest roads, where it used to be guided by the light of demonstration,—is one of the most singular facts in the history of human knowledge.

The degree of acrimony and illiberality which were sometimes mixed in this controversy was not very creditable to the disputants, and proved how much more men take an interest in opinions as being their own, than as being simply in themselves either true or false. The dispute, as conducted by S'Gravesande and Clarke, took this turn, especially on the part of the latter, who, in the schools of theology having sharpened both his temper and his wit, accompanied his reasonings with an insolence and irritability peculiarly ill suited to a discussion about matter and motion. His paper on this subject, in the *Philosophical Transactions*,[1] contains many just and acute remarks, accompanied with the most unfair representation of the argument of his antagonists, as if the doctrine of the *vis viva* were a matter of as palpable absurdity as the denial of one of the axioms of geometry.[2] Now, the truth is, that the argument in favour of living forces is not at all liable to this reproach. One of the effects produced by a moving body is proportional to the square of the velocity, while another is proportional to the velocity simply; and, according to which of these ways the force itself is to be measured, may involve the propriety or impropriety of mathematical language, but cannot be charged with absurdity or contradiction. Absurdity, indeed, was a reproach that neither side had any right to cast on the other.

A Dissertation of Mairan, on the Force of moving Bodies, in the *Memoirs of the Academy of Sciences* for 1728, is one of those in which the common measure of force is most ably supported. Nevertheless, for a long time after this, the opinions on that subject in France continued still to be divided. In the list of the disputants we should hardly expect to find a lady included, if we did not know that the name of Madame du Chastelet, along with those of Hypatia and Agnesi, was honourably enrolled in the annals of mathematical learning. Her writings on this subject are full of ingenuity, though, from the fluctuation of her opinions,[1] it seems as if she had not yet entirely exchanged the caprice of fashion for the austerity of science. About the same time Voltaire engaged in the argument, and in a Memoir,[2] presented to the Academy of Sciences in 1741, contended that the dispute was entirely about words. His reasoning is, on the whole, sound; and the suffrage of one who united the character of a wit, a poet, and a philosopher, must be of great importance in a country where the despotism of fashion extends even to philosophical opinion.

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[1] Vol. XXXV. (1728) p. 381: Hutton's Abridgement, vol. VII. p. 219.

[2] In all the arguments for the *vis viva*, this learned metaphysician saw nothing but a conspiracy formed against the Newtonian philosophy. "An extraordinary instance," says he, "of the maintenance of the most palpable absurdity we have had of late years in very eminent mathematicians, Leibnitz, Bernoulli, Hermann, S'Gravesande, who, in order to raise a dust of opposition against the Newtonian philosophy, some years back insisted with great eagerness on a principle which subverts all science, and which may easily be made appear, even to an ordinary capacity, to be contrary to the necessary and essential nature of things." This passage may serve as a proof of the spirit which prevailed among the philosophers of that time, making them ascribe such illiberal views to one another, and distorting so entirely both their own reasoning and those of their adversaries. The spirit awakened by the discovery of fluxions had not yet subsided.

The controversy was now drawing to a conclusion,[3] and in effect may be said to have been terminated by the publication of D'Alembert's *Dynamique* in 1743. I am not certain, however, that all the disputants acquiesced in this decision, at least till some years later. Dr Reid, in an Essay on Quantity, in the *Philosophical Transactions* for 1748, has treated of this controversy, and remarked, that it had been dropt rather than concluded. In this I confess I differ from the learned author. The controversy seemed fairly ended, the arguments exhausted, and the conclusion established, that the propositions maintained by both sides were true, and were not opposed to one another. Though the mathematical sciences cannot boast of never having had any debates, they can say that those that have arisen have always been brought to a satisfactory termination.

The observations with which I am to conclude the present sketch, are not precisely the same with those of the French philosopher, though they rest nearly on the same foundation.

As the effects of moving bodies, or the changes they produce, may vary considerably with accidental circumstances, we must, in order to measure their force, have recourse to effects which are uniform, and not under the influence of variable causes. First, we may measure the force of one moving body by its effect upon another moving body; and here there is no room for dispute, nor any doubt that the forces of such bodies are as the quantities of matter multiplied into the simple power of the velocities, because the forces of bodies in which these products are equal, are well known, if opposed, to destroy one another. Thus one effect of moving bodies affords a measure of their force, which does not vary as the *square*, but as the *simple power* of the velocity.

There is also another condition of moving bodies which may be expected to afford a simple and general measure of their force. When a moving body is opposed by pressure, by a *vis mortua*, or a resistance like that of gravity, the quantity of such resistance required to extinguish the motion, and reduce the body to rest, must serve to measure the force of that body. It is a force which, by repeated impulses, has annihilated another; and these impulses, when properly collected into one sum, must evidently be equal to the force which they have extinguished. It happens, however, that there are two ways of computing the amount of these retarding forces, which lead to different results, both of them just, and neither of them to be assumed to the exclusion of the other.

Suppose the body, the force of which is to be measured, to be projected perpendicularly upward with any velocity; then, if we would compute the quantity of the force of gravity which is employed in reducing it to rest, we may either inquire into the retardation which that force produces during a given time, or while the body is moving over a given space. In other words, we may either inquire how long the motion will continue, or how far it will carry the body before it be entirely exhausted. If the length of the time that the uniform resistance must act before it reduce the body to rest be taken for the effect, and consequently for the measure of the force of the body, that force must be proportional to the velocity, for to this the time is confessedly proportional. If, on the other hand, the length of the line which the moving body describes, while subjected to this uniform resistance, be taken for the effect and the measure of the force, the force must be as the square of the velocity, because to that quantity the line in question is known to be proportional. Here, therefore, are two results, or two values of the same thing, the force of a moving body, which are quite different from one another; an inconsistency which evidently arises from this, that the thing denoted by the term *force* is too vague and indefinite to be capable of measurement, unless some further condition be annexed. This condition is no other than a specification of the work to be performed, or of the effect to be produced by the action of the moving body. Thus, when to the question concerning the force of the moving body you add that it is to be employed in putting in motion another body which is itself free to move, no doubt remains that the force is as the velocity multiplied into the quantity of matter. So also, if the force of the moving body is to be opposed by a resistance like that of gravity, the length of time that the motion may continue is one of its measurable effects, and that effect is, like the former, proportional to the velocity. There is a third effect to be considered, and one which always occurs in such an experiment as the last,—the height to which the moving body will ascend. This limitation gives to the force a definite character, and it is now measured by the square of the velocity. In fact, therefore, it is not a precise question to ask, What is the measure of the force of a moving body? You must, in addition, say, How is the moving body to be employed, or in which of its different capacities is it that you would measure its effect? In this state of the question there is no ambiguity, nor any answer to be given but one. Hence it was that the mathematicians and philosophers who differed so much about the general question of the force of moving bodies, never differed about the particular applications of that force. It was because the condition necessary for limiting the vagueness and ambiguity of the data, in all such cases, was fully supplied.

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[1] Madame du Chastelet, in a Dissertation on Fire, published in 1740, took the side of Mairan, and bestowed great praise on his discourse on the Force of moving Bodies. Having, however, afterwards become a convert to the philosophy of Leibnitz, she espoused the cause of the *vis viva*, and wrote against Mairan. At this time too she drew up a compend of the Leibnitian philosophy for the use of her son, which displays ingenuity and acuteness, and is certainly such a present as very few mothers have ever been in a condition to make to their children. Soon afterwards the same lady, having become a Newtonian, returned to her former opinion about the force of moving bodies, and in the end, gave to her countrymen an excellent translation of the *Principia* of Newton, with a commentary on a part of it, far superior to any other that has yet appeared.

[2] *Doutes sur la Mésure des Forces Motrices : Œuvres* de Voltaire, tom. XXXIX. p. 91. 8vo edit. 1785.

[3] Two very valuable papers that appeared at this late period of the dispute are found in the *Philosophical Transactions;* one by Desaguliers, in 1733, full of excellent remarks and valuable experiments; another by Jurin, in 1745, containing a very full state of the whole controversy.

In the argument, therefore, so strenuously maintained on the force of moving bodies, both sides were partly in the right and both partly in the wrong. Each produced a measure of force which was just in certain circumstances, and thus far had truth on his side: but each argued that his was the only true measure, so that all others ought to be rejected; and here each of them was in error. Hence, also, it is not an accurate account of the controversy to say that it was about words merely: the disputants did indeed misunderstand one another; but their error lay in ascribing generality to propositions that were true only in particular cases, to which indeed the ambiguity and vagueness of the word *force* materially contributed. It does not appear, however, that any good would now accrue from changing the language of dynamics. If, as has been already said, to the question, How are we to measure the force of a moving body? be added the nature of the effect which is to be produced, all ambiguity will be avoided.

It is, I think, only further necessary to observe, that when the resistance opposed to the moving body is not uniform but variable, according to any law, it is not simply either the time or the space which is proportional to the velocity or to the square of the velocity, but functions of those quantities. These functions are obtained from the integration of certain fluxionary expressions, in which the measures above described are applied, the resistance being regarded as uniform for an infinitely small portion of the time or of the space.

Many years after the period I am now treating of, the controversy about the *vis viva* seemed to revive in England, on the occasion of an Essay on Mechanical Force, by the late Mr Smeaton, an able engineer, who, to great practical skill, and much experience, added no inconsiderable knowledge of the Mathematics.

The reality of the *vis viva*, then, under certain conditions, is to be considered as a matter completely established. Another inquiry concerning the nature of this force, which also gave rise to considerable debate, was, whether, in the communication of motion, and in the various changes through which moving bodies pass, the quantity of the *vis viva* remains always the same. It had been observed, in the collision of elastic bodies, that the *vis viva*, or the sum made up by multiplying each body into the square of its velocity, and adding the products together, was the same after collision that it was before it; and it was concluded with some precipitation, by those who espoused the Leibnitian theory, that a similar result always took place in the real phenomena of nature. Other instances were cited; and it was observed, that a particular view of this principle which presented itself to Huygens, had enabled him to find the centre of oscillation of a compound pendulum, at a time when the state of mechanical science was scarcely prepared for so difficult an investigation. The proposition, however, is true only when all the changes are gradual, and rigorously subjected to the law of continuity. Thus, in the collision of bodies imperfectly elastic, (a case which continually occurs in nature) the force which, during the recoil, accelerates the separation of the bodies, does not restore to them the whole velocity they had lost; and the *vis viva*, after the collision, is always less than it was before it. The cases in which the whole amount of the *vis viva* is rigorously preserved, may always be brought under the thirty-ninth proposition of the first book of the *Principia*, where the principle of this theory is placed on its true foundation.

So far as general principles are concerned, the preceding are the chief mechanical improvements which belong to the period so honourably distinguished by the names of Newton and Leibnitz. The application of these principles to the solution of particular problems would afford materials for more ample discussion than suits the nature of an historical outline. Such problems as that of finding the centre of oscillation,—the nature of the catenarian curve,—the determination of the line of swiftest descent,—the retardation produced to motion in a medium that resists according to the square of the velocity, or indeed according to any function of it,—the determination of the elastic curve, or that into which an elastic spring forms itself when a force is applied to bend it;—all these were problems of the greatest interest, and were now resolved for the first time; the science of mechanics being sufficient, by means of the composition of forces, to find out the fluxionary or differential equations which expressed the nature of the gradual changes which in all these cases were produced, and the calculus being now sufficiently powerful to infer the properties of the finite from those of the infinitesimal quantities.

The doctrine of Hydrostatics was cultivated in England by Cotes. The properties of the atmosphere, or of elastic fluids, were also experimentally investigated; and the barometer, after the ingenuity of Pascal had proved that the mercury stood lower the higher up into the atmosphere the instrument was carried, was at length brought to be a measure of the height of mountains. Mariotte appears to have been the first who proposed this use of it, and who discovered that, while the height from the ground increases in arithmetical, the density of the atmosphere and the column of mercury in the barometer decrease in geometrical progression. Halley, who seems also to have come of himself to the same conclusion, proved its truth by strict geometrical reasoning, and showed that logarithms are easily applicable on this principle to the problem of finding the height of mountains. This was in the year 1685. Newton two years afterwards gave a demonstration of the same, extended to the case when gravity is not constant, but varies as any power of the distance from a given centre.

To the assiduous observations and the indefatigable activity of Halley, the natural history of the atmosphere, of the ocean, and of magnetism, are all under the greatest obligations. For the purpose of inquiring into these objects, this ardent and philosophical observer relinquished the quiet of academical retirement, and, having gone to St Helena, by a residence of a year in that island, not only made an addition to the catalogue of the stars, of 360 from the southern hemisphere, but returned with great acquisitions both of nautical and meteorological knowledge.

His observations on evaporation were the foundation of two valuable papers on the origin of fountains; in which, for the first time, the sufficiency of the vapour taken up into the atmosphere, to maintain the perennial flow of springs and rivers, was established by undeniable evidence. The difficulty which men found in conceiving how a precarious and accidental supply like that of the rains can sufficiently provide for a great and regular expenditure like that of the rivers, had given rise to those various opinions concerning the origin of fountains, which had hitherto divided the scientific world. A long residence on the summit of an insulated rock, in the midst of a vast ocean, visited twice every year by the vertical sun, would have afforded to an observer less quick-sighted than Halley, an opportunity of seeing the work of evaporation carried on with such rapidity and copiousness as to be a subject of exact measurement. From this extreme ease, he could infer the medium quantity, at least by approximation; and he proved that, in the Mediterranean, the humidity daily raised up by evaporation is three times as great as that which is discharged by all the rivers that flow into it. The origin of fountains was no longer questioned; and of the multitude of opinions on that subject, which had hitherto perplexed philosophers, all but one entirely disappeared.[1]

Beside the voyage to St Helena, Halley made two others; the British government having been enlightened and liberal enough to despise professional etiquette, where the interests of science were at stake, and to intrust to a Doctor of Laws the command of a ship of war, in which he traversed the Atlantic and Pacific Oceans in various directions, as far as the 53d degree of south latitude, and returned with a collection of facts and observations for the improvement of geography, meteorology, and navigation, far beyond that which any individual traveller or voyager had hitherto brought together.

The variation of the compass was long before this time known to exist, but its laws had never yet been ascertained. These Halley now determined from his own observations, combined with those of former navigators, in so far as to trace, on a nautical chart, the lines of the same variation over a great part both of the Atlantic and Pacific Oceans, affording to the navigator the ready means of correcting the errors which the deviation of the needle from the true meridian was calculated to produce. In his different traverses he had four times intersected the line of no variation, which seemed to divide the earth into two parts, the variations on the east side being towards the west, and on the west side towards the east. These lines being found to change their position in the course of time, the place assigned to the magnetical poles could not be permanent. Any theory, therefore, which could afford an explanation of their changes, must necessarily be complex and difficult to be established. The attempt of Halley to give such an explanation, though extremely ingenious, was liable to great objections; and while it has shared the fate of most of the theories which have been laid down before the phenomena had been sufficiently explored, the general facts which he established have led to most of the improvements and discoveries which have since been made respecting the polarity of the needle.

Besides the conclusion just mentioned, Dr Halley derived from his observations a very complete history of the winds which blow in the tropical regions, viz. the trade-wind and the monsoons, together with many interesting facts concerning the phenomena of the tides. The chart which contained an epitome of all these facts was published in 1701.

The above are only a part of the obligations which the sciences are under to the observations and reasonings of this ingenious and indefatigable inquirer. Halley was indeed one of the ablest and most accomplished men of his age. A scholar well versed in the learned languages, and a geometer profoundly skilled in the ancient analysis, he restored to their original elegance some of the precious fragments of that analysis, which time happily had not entirely defaced. He was well acquainted also with the algebraical and fluxionary calculus, and was both in theory and practice a profound and laborious astronomer. Finally, he was the friend of Newton, and often stimulated, with good effect, the tardy purposes of that great philosopher. Few men, therefore, of any period, have more claims than Halley on the gratitude of succeeding ages.

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[1] *Philosophical Transactions*, 1687, vol. XVI. p. 366.

The invention of the thermometer has been already noticed; and the improvements made on that instrument about this period laid the foundation of many future discoveries. The discovery of two fixed temperatures, each marked by the same expansion of the mercury in the thermometer, and the same condition of the fluid in which it is immersed, was made about this time. The differences of temperature were thus subjected to exact measurement; the phenomena of heat became, of course, known with more certainty and precision; and that substance or virtue, to which nothing is impenetrable, and which finds its way through the rarest and the densest bodies apparently with the same facility,—which determines so many of our sensations, and of which the distribution so materially influences all the phenomena of animal and vegetable life,—came now to be known, not indeed in its essence, but as to all the characters in which we are practically or experimentally concerned. The treatise on Fire, in Boerhaave's *Chemistry*, is a great advance beyond any thing on that subject hitherto known, and touches, notwithstanding many errors and imperfections, on most of the great truths which time, experience, and ingenuity, have since brought into view.

It was in this period also that electricity may be said first to have taken a scientific form. The power of amber to attract small bodies after it has been rubbed, is said to have been known to Thales, and is certainly made mention of by Theophrastus. The observations of Gilbert, a physician of Colchester, in the end of the sixteenth century, though at the distance of two thousand years, made the first addition to the transient and superficial remarks of the Greek naturalist, and afford a pretty full enumeration of the bodies which can be rendered electrical by friction. The Academia del Cimento, Boyle, and Otto Guericke, followed in the same course; and the latter is the first who mentions the crackling noise and faint light which electricity sometimes produced. These, however, were hardly perceived, and it was by Dr Wall, as described in the *Philosophical Transactions*, that they were first distinctly observed.[1] By a singularly fortunate anticipation, he remarks of the light and crackling, that they seemed in some degree to represent thunder and lightning.

After the experiments of Hauksbee in 1709, by which the knowledge of this mysterious substance was considerably advanced, Wheeler and Gray, who had discovered that one body could communicate electricity to another without rubbing, being willing to try to what distance the electrical virtue might be thus conveyed, employed, for the purpose of forming the communication, a hempen rope, which they extended to a considerable length, supporting it from the sides by threads, which, in order to prevent the dissipation of the electricity, they thought it proper to make as slender as possible. They employed silk threads with that view, and found the experiment to succeed. Thinking that it would succeed still better if the supports were made still more slender, they tried very fine metallic wire, and were surprised to find that the hempen rope, thus supported, conveyed no electricity at all. It was therefore as being *silk*, and not as being *small*, that the threads had served to retain the electricity. This accident led to the great distinction of substances conducting and not conducting electricity. An extensive field of inquiry was thus opened, a fortunate accident having supplied an *instantia crucis*, and enabled these experimenters to distinguish between what was essential and what was casual in the operation they had performed. The history of electricity, especially in its early stages, abounds with facts of this kind; and no man who would study the nature of inductive science, and the rules for the interpretation of nature, can employ himself better than in tracing the progress of these discoveries. He will find abundant reason to admire the ingenuity as well as the industry of the inquirers, but he will often find accident come in very opportunely to the assistance of both. The experiments of Wheeler and Gray are described in the *Transactions* for 1729.

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[1] Wall's paper is in the *Transactions* for 1708, vol. XXVI. No. 314. p. 69. Hauksbee on Electrical Light, in the same volume. See Abridgement, vol. V. p. 408, 411.

SECTION III.

OPTICS.

The invention of the telescope and the microscope, the discoveries made concerning the properties of light and the laws of vision, added to the facility of applying mathematical reasoning as an instrument of investigation, had long given a peculiar interest to optical researches. The experiments and inquiries of Newton on that subject began in 1666, and soon made a vast addition both to the extent and importance of the science. He was at that time little more than twenty-three years old; he had already made some of the greatest and most original discoveries in the pure mathematics; and the same young man, whom we have been admiring as the most profound and inventive of geometers, is to appear, almost at the same moment, as the most patient, faithful, and sagacious interpreter of nature. These characters, though certainly not opposed to one another, are not often combined; but to be combined in so high a degree, and in such early life, was hitherto without example.

In hopes of improving the telescope, by giving to the glasses a figure different from the spherical, he had begun to make experiments, and had procured a glass prism, in order, as he tells us, to try with it the *celebrated phenomena of colours.*[1] These trials led to the discovery of the different refrangibility of the rays of light, and are now too well known to stand in need of a particular description.

Having admitted a beam of light into a dark chamber, through a hole in the window-shutter, and made it fall on a glass prism, so placed as to cast it on the opposite wall, he was delighted to observe the brilliant colouring of the sun's image, and not less surprised to observe its figure, which, instead of being circular, as he expected, was oblong in the direction perpendicular to the edges of the prism, so as to have the shape of a parallelogram, rounded at the two ends, and nearly five times as long as it was broad.

When he reflected on these appearances, he saw nothing that could explain the elongation of the image, but the supposition that some of the rays of light, in passing through the prism, were more refracted than others; so that rays which were parallel when they fell on the prism, diverged from one another after refraction, the rays that differed in refrangibility differing also in colour. The *spectrum*, or solar image, would thus consist of a series of circular images, partly covering one another, and partly projecting one beyond another, from the red or least refrangible rays, in succession, to the orange, yellow, green, blue, indigo, and violet, the most refrangible of all.

It was not, however, till he tried every other hypothesis which suggested itself to his mind by the test of experiment, and proved its fallacy, that he adopted this as a true interpretation of the phenomena. Even after these rejections, his explanation had still to abide the sentence of an *experimentum crucis.*

Having admitted the light and applied a prism as before, he received the coloured spectrum on a board at the distance of about twelve feet from the first, and also pierced with a small hole. The coloured light which passed through this second hole was made to fall on a prism, and afterwards received on the opposite wall. It was then found that the rays which had been most refracted, or most bent from their course by the first prism, were most refracted also by the second, though no new colours were produced. "So," says he, "the true cause of the length of the image was detected to be no other than that light consists of rays differently refrangible, which, without any respect to a difference in their incidence, were, according to their degrees of refrangibility, transmitted towards divers parts of the wall." [1]

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[1] *Philosophical Transactions*, vol. VI. (1672) p. 3075: also Hutton's Abridgement, vol. I. p. 678. The account of the experiments is in a letter to Oldenburg, dated February 1672: it is the first of Newton's works that was published. It is plain, from what is said above, that the phenomena of the prismatic spectrum were not unknown at that time, however little they were understood, and however imperfectly observed.

It was also observed, that when the rays which fell on the second prism were all of the same colour, the image formed by refraction was truly circular, and of the same colour with the incident light. This is one of the most conclusive and satisfactory of all the experiments.

When the sun's light is thus admitted, first through one aperture, and then through another at some distance from the first, and is afterwards made to fall on a prism, as the rays come only from a part of the sun's disk, the spectrum has nearly the same length as before, but the breadth is greatly diminished; in consequence of which, the light at each point is purer, it is free from penumbra, and the confines of the different colours can be more accurately traced. It was in this way that Newton measured the extent of each colour; and taking the mean of a great number of measures, he assigned the following proportions, dividing the whole length of the spectrum, exclusive of its rounded terminations, into 360 equal parts: of these the

Red occupied - -	45
Orange - -	27
Yellow - - -	48
Green - -	60
Blue - - -	60
Indigo - -	40
Violet - - -	80

Between the divisions of the spectrum, thus made by the different colours, and the divisions of the monochord by the notes of music, Newton conceived that there was an analogy, and indeed an identity of ratios; but experience has since shown that this analogy was accidental, as the spaces occupied by the different colours do not divide the spectrum in the same ratio, when prisms of different kinds of glass are employed.

Such were the experiments by which Newton first "untwisted all the shining robe of day," and made known the texture of the magic garment which nature has so kindly spread over the surface of the visible world. From them it followed, that colours are not qualities which light derives from refraction or reflection, but are original and connate properties connected with the different degrees of refrangibility that belong to the different rays. The same colour is always joined to the same degree of refrangibility; and conversely, the same degree of refrangibility to the same colour.

Though the seven already enumerated are primary and simple colours, any of them may also be produced by a mixture of others. A mixture of yellow and blue, for instance, makes green; of red and yellow, orange; and, in general, if two colours which are not very far asunder in the natural series be mixed together, they compound the colour that is in the middle between them.

But the most surprising composition of all, Newton observes, is that of whiteness; which is not produced by one sort of rays, but by the mixture of all the colours in a certain proportion, namely, in that proportion which they have in the solar spectrum. This fact may be said to be made out both by analysis and composition. The white light of the sun can be separated, as we have just seen, into the seven simple colours; and if these colours be united again, they form white. Should any of them have been wanting, or not in its due proportion, the white produced is defective.

It appeared, too, that natural bodies, of whatever colour, if viewed by simple and homogeneous light, are seen of the colour of that light, and of no other. Newton tried this very satisfactory experiment on bodies of all colours, and found it to hold uniformly; the light was never changed by the colour of the body that reflected it.

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[1] *Philosophical Transactions*, vol. VI. (1672) No. 80. p. 3075.

Newton, thus furnished with so many new and accurate notions concerning the nature and production of colour, proceeded to apply them to the explanation of phenomena. The subject which naturally offered itself the first to this analysis was the rainbow, which, by the grandeur and simplicity of its figure, added to the brilliancy of its colours, in every age has equally attracted the attention of the peasant and of the philosopher. That two refractions and one reflection were at least a part of the machinery which nature employed in the construction of this splendid arch, had been known from the time of Antonio de Dominis; and the manner in which the arched figure is produced had been shown by Descartes; so that it only remained to explain the nature of the colour and its distribution. As the colours were the same with those exhibited by the prism, and succeeded in the same order, it could hardly be doubted that the cause was the same. Newton showed the truth of his principles by calculating the extent of the arch, the breadth of the coloured bow, the position of the secondary bow, its distance from the primary, and by explaining the inversion of the colours.[1] There is not, perhaps, in science any happier application of theory, or any in which the mind rests with fuller confidence.

Other meteoric appearances seemed to be capable of similar explanations, but the phenomena being nowhere so regular or so readily subjected to measurement as those of the rainbow, the theory cannot be brought to so severe a test, nor the evidence rendered so satisfactory.

But a more difficult task remained,—to explain the permanent colour of natural bodies. Here, however, as it cannot be doubted that all colour comes from the rays of light, so we must conclude that one body is red and another violet, because the one is disposed to reflect the red or least refrangible rays, and the other to reflect the violet or the most refrangible. Every body manifests its disposition to reflect the light of its own peculiar colour, by this, that if you cast on it pure light, first of its own colour, and then of any other, it will reflect the first much more copiously than the second. If cinnabar, for example, and ultramarine blue be both exposed to the same red homogeneous light, they will both appear red, but the cinnabar strongly luminous and resplendent, and the ultramarine of a faint obscure red. If the homogeneal light thrown on them be blue, the converse of the above will take place.

Transparent bodies, particularly fluids, often transmit light of one colour and reflect light of another. Halley told Newton, that, being deep under the surface of the sea in a diving-bell, in a clear sunshine day, the upper side of his hand, on which the sun shone darkly through the water and through a small glass window in the diving-bell, appeared of a red colour, like a damask rose, while the water below, and the under part of his hand, looked green.[2]

But, in explaining the permanent colour of bodies, this difficulty always presents itself:—Suppose that a body reflects red or green light, what is it that decomposes the light, and separates the red or the green from the rest? Refraction is the only means of decomposing light, and separating the rays of one degree of refrangibility, and of one colour, from those of another. This appears to have been what led Newton to study the colours produced by light passing through thin plates of any transparent substance. The appearances are very remarkable, and had already attracted the attention both of Boyle and of Hooke; but the facts observed by them remained insulated in their hands, and unconnected with other optical phenomena.

It probably had been often remarked, that when two transparent bodies, such as glass, of which the surfaces were convex in a certain degree, were pressed together, a black spot was formed at the contact of the two, which was surrounded with coloured rings, more or less regular, according to the form of the surfaces. In order to analyze a phenomenon that seemed in itself not a little curious, Newton proposed to make the experiment with surfaces of a regular curvature, such as was capable of being measured. He took two object-glasses, one a plano-convex for a fourteen feet telescope, the other a double convex for one of about fifty feet, and upon this last he laid the other with its plane side downwards, pressing them gently together. At their contact in the centre was a pellucid spot, through which the light passed without suffering any reflection. Round this spot was a coloured circle or ring, exhibiting blue, white, yellow, and red. This was succeeded by a pellucid or dark ring, then a coloured ring of violet, blue, green, yellow, and red, all copious and vivid except the green. The third coloured ring consisted of purple, blue, green, yellow, and red. The fourth consisted of green and red; those that succeeded became gradually more dilute, and ended in whiteness. It was possible to count as far as seven.

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[1] *Optics*, book i. part ii. prop. 9.

[2] *Ibid.* book i. part ii. prop. 10.

The colours of these rings were so marked by peculiarities in shade and vivacity, that Newton considered them as belonging to different orders; so that an eye accustomed to examine them, on any particular colour of a natural object being pointed out, would be able to determine to what order in this series it belonged.

Thus we have a system of rings or zones surrounding a dark central spot, and themselves alternately dark and coloured, that is, alternately transmitting the light and reflecting it. It is evident that the thickness of the plates of air interposed between the glasses, at each of those rings, must be a very material element in the arrangement of this system. Newton therefore undertook to compute their thickness. Having carefully measured the diameters of the first six coloured rings, at the most lucid part of each, he found their squares to be as the progression of odd numbers 1, 3, 5, 7, &c. The squares of the distances from the centre of the dark spot to each of these circumferences were, therefore, in the same ratio, and consequently the thickness of the plates of air, or the intervals between the glasses, was as the numbers 1, 3, 5, 7, &c.

When the diameters of the dark or pellucid rings which separated the coloured rings were measured, their squares were found to be as the even numbers 0, 2, 4, 6; and, therefore, the thickness of the plates through which the light was wholly transmitted was as the same numbers. A great many repeated measurements assured the accuracy of these determinations.

As the curvature of the convex glass on which the flat surface of the plano-convex rested was known, and as the diameters of the rings were measured in inches, it was easy to compute the thickness of the plates of air, which corresponded to the different rings.

An inch being divided into 178000 parts, the distance of the lenses for the first series, or for the luminous rings, was $\frac{1}{178000}$, $\frac{3}{178000}$, $\frac{5}{178000}$, &c.
For the second series $\frac{2}{178000}$, $\frac{4}{178000}$, &c.

When the rings were examined by looking through the lenses in the opposite direction, the central spot appeared white, and, in other rings, red was opposite to blue, yellow to violet, and green to a compound of red and violet; the colours formed by the transmitted and the reflected light being what is now called complementary, or nearly so, of one another; that is, such as, when mixed, produce white.

When the fluid between the glasses was different from air, as when it was water, the succession of rings was the same; the only difference was, that the rings themselves were narrower.

When experiments on thin plates were made in such a way that the plate was of a denser body than the surrounding medium, as in the case of soap-bubbles, the same phenomena were observed to take place. These phenomena Newton also examined with his accustomed accuracy, and even bestowed particular care on having the soap-bubbles as perfect and durable as their frail structure would admit. In the eye of philosophy no toy is despicable, and no occupation frivolous, that can assist in the discovery of truth.

To the different degrees of tenuity, then, in transparent substances, there seemed to be attached the powers of separating particular colours from the mass of light, and of rendering them visible sometimes by reflection, and, in other cases, by transmission. As there is reason to think, then, that the minute parts, the mere particles of all bodies, even the most opaque, are transparent, they may very well be conceived to act on light after the manner of the thin plates, and to produce each, according to its thickness and density, its appropriate colour, which, therefore, becomes the colour of the surface. Thus the colours in which the bodies round us appear everywhere arrayed, are reducible to the action of the parts which constitute their surfaces on the refined and active fluid which pervades, adorns, and enlightens the world.

But the same experiments led to some new and unexpected conclusions, that seemed to reach the very essence of the fluid of which we now speak. It was impossible to observe, without wonder, the rings alternately luminous and dark that were formed between the two plates of glass in the preceding experiments, and determined to be what they were by the different thickness of the air between the plates, and having to that thickness the relations formerly expressed. A plate of which the thickness was equal to a certain quantity multiplied by an odd number, gave always a circle of the one kind; but if the thickness of the plate was equal to the same quantity multiplied by an even number, the circle was of another kind, the light, in the first case, being reflected, in the second transmitted. Light penetrating a thin transparent plate, of which the thickness was *m*, 3*m*, 5*m*, &c. was decomposed and reflected; the same light penetrating the same plate, but of the thickness 0, 2*m*, 4*m*, was transmitted, though, in a certain degree, also decomposed. The same light, therefore, was transmitted or reflected, according as the second surface of the plate of air through which it passed was distant from the first by the intervals 0, 2, 4*m*, or *m*, 3*m*, 5*m*; so that it becomes necessary to suppose the same ray to be successively disposed to be transmitted and to be reflected at points of space separated from one another by the same interval *m*. This constitutes what Newton called *fits of easy transmission and easy reflection*, and forms one of the most singular parts of his optical discoveries. It is so unlike any thing which analogy teaches us to expect, that it has often been viewed with a degree of incredulity, and regarded as at best but a conjecture introduced to account for certain optical phenomena. This, however, is by no means a just conclusion; for it is, in reality, a necessary inference from appearances accurately observed, and is no less entitled to be considered as a fact than those appearances themselves. The difficulty of assigning a cause for such extraordinary alternations cannot be denied, but does not entitle us to doubt the truth of a conclusion fairly deduced from experiment. The principle has been confirmed by phenomena that were unknown to Newton himself, and possesses this great and unequivocal character of philosophic truth, that it has served to explain appearances which were not observed till long after the time when it first became known.

We cannot follow the researches of Newton into what regards the colours of thick plates, and of bodies in general. We must not, however, pass over his explanation of refraction, which is among the happiest to be met with in any part of science, and has the merit of connecting the principles of optics with those of dynamics.

The theory from which the explanation we speak of is deduced is, that light is an emanation of particles, moving in straight lines with incredible velocity, and attracted by the particles of transparent bodies. When, therefore, light falls obliquely on the surface of such a body, its motion may be resolved into two, one parallel to that surface, and the other perpendicular to it. Of these, the first is not affected by the attraction of the body, which is perpendicular to its own surface; and, therefore, it remains the same in the refracted that it was in the incident ray. But the velocity perpendicular to the surface is increased by the attraction of the body, and, according to the principles of dynamics, (the 39th, book i. *Princip.*) whatever be the quantity of this velocity, its square, on entering the same transparent body, will always be augmented by the same quantity. But it is easy to demonstrate that, if there be two right-angled triangles, with a side in the one equal to a side in the other, the hypotheneuse of the first being given, and the squares of their remaining sides differing by a given space, the sines of the angles opposite to the equal sides must have a given ratio to one another.[1] This amounts to the same with saying, that, in the case before us, the sine of the angle of incidence is to the sine of the angle of refraction in a given ratio. The explanation of the law of refraction thus given is so highly satisfactory, that it affords a strong argument in favour of the system which considers light as an emanation of particles from luminous bodies, rather than the vibrations of an elastic fluid. It is true that Huygens deduced from this last hypothesis an explanation of the law of refraction, on which considerable praise was bestowed in the former part of this Dissertation. It is undoubtedly very ingenious, but does not rest on the same solid and undoubted principles of dynamics with the preceding, nor does it leave the mind so completely satisfied. Newton, in his *Principia*, has deduced another demonstration of the same optical proposition from the theory of central forces.[2]

The different refrangibility of the rays of light forms no exception to the reasoning above. The rays of each particular colour have their own particular ratio subsisting between the sines of incidence and refraction; or, in each, the square that is added to the square of the perpendicular velocity has its own value, which continues the same while the transparent medium is the same.

Light, in consequence of these views, became, in the hands of Newton, the means of making important discoveries concerning the internal and chemical constitution of bodies. The square that is added to that of the perpendicular velocity of light in consequence of the attractive force of the transparent substance, is properly the measure of the quantity of that attraction, and is the same with the difference of the squares of the velocities of the incident and the refracted light. This is readily deduced, therefore, from the ratio of the angle of incidence to that of refraction; and when this is done for different substances, it is found that the above measure of the refracting power of transparent bodies is nearly proportional to their density, with the exception of those which contain much inflammable matter in their composition, or sulphur as it was then called, which is always accompanied with an increase of refracting power.[3]

Thus, the refracting power, ascertained as above, when divided by the density, gives quotients not very different from one another, till we come to the inflammable bodies, where a great increase immediately takes place. In air, for instance, the quotient is 5208, in rock-crystal 5450, and the same nearly in common glass. But in spirit of wine, oil, amber, the same quotients are 10121, 12607, 13654. Newton found in the diamond, that this quotient is still greater than any of the preceding, being 14556.[4] Hence he conjectured, what has since been so fully verified by experiment, that the diamond, at least in part, is an inflammable body. Observing, also, that the refracting power of water is great for its density, the quotient, expounding it as above, being 7845, he concluded, that an inflammable substance enters into the composition of that fluid,—a conclusion which has been confirmed by one of the most certain but most unexpected results of chemical analysis. The views thus suggested by Newton have been successfully pursued by future inquirers, and the action of bodies on light is now regarded as one of the means of examining into their internal constitution.

I should have before remarked, that the alternate disposition to be easily reflected and easily transmitted serves to explain the fact, that all transparent substances reflect a portion of the incident light. The reflection of light from the surfaces of opaque bodies, and from the anterior surfaces of transparent bodies, appears to be produced by a repulsive force exerted by those surfaces at a determinate but very small distance, in consequence of which there is stretched out over them an elastic web, through which the particles of light, notwithstanding their incredible velocity, are not always able to penetrate.[5] In the case of a transparent body, the light, which, when it arrives at this outwork, as it may be called, is in a *fit* of easy reflection, obeys of course the repulsive force, and is reflected back again. The particles, on the other hand, which are in the state which disposes them to be transmitted, overcome the repulsive force, and, entering into the interior of the transparent body, are subjected to the action of its attractive force, and obey the law of refraction already explained. If these rays, however, reach the second surface of the transparent body (that body being supposed denser than the medium surrounding it) in a direction having a certain obliquity to that surface, the attraction will not suffer the rays to emerge into the rarer medium, but will force them to return back into the transparent body. Thus, the reflection of light at the second surface of a transparent body is produced, not by the repulsion of the medium in which it was about to enter, but by the attraction of that which it was preparing to leave.

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[1] *Optics*, book ii. part iii. prop. 10.

[2] *Princip. Math.* lib. i. prop. 94: also *Optics*, book i. part i. prop. 6.

[3] *Optics*, book i. part i. prop. 6.

[4] Ibid.

[5] A velocity that enables light to pass from the sun to the earth in 8′ 13″, as is deduced from the eclipses of Jupiter's satellites.

The first account of the experiments from which all these conclusions were deduced, was given in the *Philosophical Transactions* for 1672, and the admiration excited by their brilliancy and their novelty may easily be imagined. Among the men of science, the most enlightened were the most enthusiastic in their praise. Huygens, writing to one of his friends, says of them, and of the truths they were the means of making known, "*Quorum respectu omnia huc usque edita jejunia sunt et prorsus puerilia.*" Such were the sentiments of the person who, of all men living, was the best able to judge, and had the best right to be fastidious, in what related to optical experiments and discoveries. But all were not equally candid with the Dutch philosopher; and though the discovery now communicated had every thing to recommend it which can arise from what is great, new, and singular; though it was not a theory or a system of opinions, but the generalization of facts made known by experiments; and though it was brought forward in the most simple and unpretending form, a host of enemies appeared, each eager to obtain the unfortunate pre-eminence of being the first to attack conclusions which the unanimous voice of posterity was to confirm. In this contention, the envy and activity of Hooke did not fail to give him the advantage; and he communicated his objections to Newton's conclusions concerning the refrangibility of light in less than a month after they had been read in the Royal Society. He admitted the accuracy of the experiments themselves, but denied that the cause of the colour is any quality residing permanently in the rays of light, any more than that the sounds emitted from the pipes of an organ exist originally in the air. An imaginary analogy between sound and light seems to have been the basis of all his optical theories. He conceived that colour is nothing but the disturbance of light by pulses propagated through it; that blackness proceeds from the scarcity, whiteness from the plenty, of undisturbed light; and that the prism acts by exciting different pulses in this fluid, which pulses give rise to the sensations of colour. This obscure and unintelligible theory (if we may honour what is unintelligible with the name of a theory) he accompanied with a multitude of captious objections to the reasonings of Newton, whom he was not ashamed to charge with borrowing from him without acknowledgement. To all this Newton replied, with the solidity, calmness, and modesty, which became the understanding and the temper of a true philosopher.

The new theory of colours was quickly assailed by several other writers, who seem all to have had a better apology than Hooke for the errors into which they fell. Among them one of the first was Father Pardies, who wrote against the experiments, and what he was pleased to call the hypothesis, of Newton. A satisfactory and calm reply convinced him of his mistake, which he had the candour very readily to acknowledge. A countryman of his, Mariotte, was more difficult to be reconciled, and, though very conversant with experiment, appears never to have succeeded in repeating the experiments of Newton. Desaguliers, at the request of the latter, repeated the experiments doubted of before the Royal Society, where Monmort, a countryman and a friend of Mariotte, was present.[1]

MM. Linus and Lucas, both of Liege, objected to Newton's experiments as inaccurate; the first, because, on attempting to repeat them, he had not obtained the same results; and the second, because he had not been able to perceive that a red object and a blue required the focal distance to be different when they were viewed through a telescope. Newton replied with great patience and good temper to both.

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[1] Montucla, tom. II.

The series was closed in 1727, by the work of an Italian author, Rizetti, who, in like manner, called in question the accuracy of experiments which he himself had not been able to repeat. Newton was now no more; but Desaguliers, in consequence of Rizetti's doubts, instituted a series of experiments which seemed to set the matter entirely at rest. These experiments are described in the *Philosophical Transactions* for 1728.

An inference which Newton had immediately drawn from the discoveries above described was, that the great source of imperfection in the refracting telescope was the different refrangibility of the rays of light, and that there were stronger reasons than either Mersenne or Gregory had suspected, for looking to reflection for the improvement of optical instruments. It was evident, from the different refrangibility of light, that the rays coming from the same point of an object, when decomposed by the refraction of a lens, must converge to different foci; the red rays, for example, to a point more distant from the lens, and the violet to one nearer by about a fifty-fourth part of the focal distance. Hence it was not merely from the aberration of the rays caused by the spherical figure of the lens that the imperfection of the images formed by refraction arose, but from the very nature of refraction itself. It was evident, at the same time, that in a combination of lenses with opposite figures, one convex, for instance, and another concave, there was a tendency of the two contrary dispersions to correct one another. But it appeared to Newton, on examining different refracting substances, that the dispersion of the coloured rays never could be corrected except when the refraction itself was entirely destroyed; for he thought he had discovered that the quantity of the refraction and of the dispersion in different substances bore always the same proportion to one another. This is one of the few instances in which his conclusions have not been confirmed by subsequent experiment; and it will, accordingly, fall under discussion in another part of this Dissertation.

Having taken the resolution of constructing a reflecting telescope, he set about doing so with his own hands. There was, indeed, at that time, no other means by which such a work could be accomplished; the art of the ordinary glass-grinder not being sufficient to give to metallic specula the polish which was required. It was on this account that Gregory had entirely failed in realizing his very ingenious optical invention.

Newton, however, himself possessed excellent hands for mechanical operations, and could use them to better purpose than is common with men so much immersed in deep and abstract speculation. It appears, indeed, that mechanical invention was one of the powers of his mind which began to unfold itself at a very early period. In some letters subjoined to a Memoir drawn up after his death by his nephew Conduit, it is said, that, when a boy, Newton used to amuse himself with constructing machines, mills, &c. on a small scale, in which he displayed great ingenuity; and it is probable that he then acquired that use of his hands which is so difficult to be learned at a later period. To this, probably, we owe the neatness and ingenuity with which the optical experiments above referred to were contrived and executed,—experiments of so difficult a nature, that any error in the manipulation would easily defeat the effect, and appears actually to have done so with many of those who objected to his experiments.[1]

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[1] The *Memoir* of Conduit was sent to Fontenelle when he was preparing the *Eloge* on Newton, but he seems to have paid little attention to it, and has passed over the early part of his life with the remark, that one may apply to him what Lucan says of the Nile, that it has not been "permitted to mortals to see that river in a feeble state." If the letters above referred to had formed a part of this communication, I think the Secretary of the Academy would have sacrificed a fine comparison to an instructive fact. In other respects Conduit's Memoir did not convey much information that could be of use. His instructions to Fontenelle are curious enough; he bids him be sure to state, that Leibnitz had borrowed the Differential Calculus from the Method of Fluxions. He conjured him in another place not to omit to mention, that Queen

He succeeded perfectly in the construction of his telescope; and his first communication with Oldenburg, and the first reference to his optical experiments, is connected with the construction of this instrument, and mentioned in a letter dated the 11th January 1672. He had then been proposed as a member of the Royal Society by the bishop of Sarum, and he says, "If the honour of being a member of the Society shall be conferred on me, I shall endeavour to testify my gratitude by communicating what my poor and solitary endeavours can effect toward the promoting its philosophical designs."[1] Such was the modesty of the man who was to effect a greater revolution in the state of our knowledge of nature than any individual had yet done, and greater, perhaps, than any individual is ever destined to bring about. Success, however, never altered the temper in which he began his researches.

Newton, after considering the reflection and refraction of light, proceeded, in the third and last book of his *Optics*, to treat of its *inflection*, a subject which, as has been remarked in the former part of this Dissertation, was first treated of by Grimaldi. Newton having admitted a ray of light through a hole in a window-shutter into a dark chamber, made it pass by the edge of a knife, or, in some experiments, between the edges of two knives, fixed parallel and very near to one another; and, by receiving the light on a sheet of paper at different distances behind the knives, he observed the coloured fringes which had been described by the Italian optician, and, on examination, found that the rays had been acted on in passing the knife-edges both by repulsive and attractive forces, and had begun to be so acted on in a sensible degree when they were yet distant by $\frac{1}{800}$ of an inch of the edges of the knives. His experiments, however, on this subject were interrupted, as he informs us, and do not appear to have been afterwards resumed. They enabled him, however, to draw this conclusion, that the path of the ray, in passing by the knife-edge, was bent in opposite directions, so as to form a serpentine line, convex and concave toward the knife, according to the repulsive or attractive forces which acted at different distances; that it was also reasonable to conclude, that the phenomena of the refraction, reflection, and inflection of light were all produced by the same force variously modified, and that they did not arise from the actual contact or collision of the particles of light with the particles of bodies.

The third book of the *Optics* concludes with those celebrated *Queries* which carry the mind so far beyond the bounds of ordinary speculation, though still with the support and under the direction either of direct experiment or close analogy. They are a collection of propositions relative chiefly to the nature of the mutual action of light and of bodies on one another, such as appeared to the author highly probable, yet wanting such complete evidence as might entitle them to be admitted as principles established. Such enlarged and comprehensive views, so many new and bold conceptions, were never before combined with the sobriety and caution of philosophical induction. The anticipation of future discoveries, the assemblage of so many facts from the most distant regions of human research, all brought to bear on the same points, and to elucidate the same questions, are never to be sufficiently admired. At the moment when they appeared, they must have produced a wonderful sensation in the philosophic world, unless, indeed, they advanced too far before the age, and contained too much which the comment of time was yet required to elucidate.

It is in the *Queries* that we meet with the ideas of this philosopher concerning the *Elastic Ether*, which he conceived to be the means of

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Caroline used to delight much in the conversation of Newton, and nothing could do more honour to Newton than the commendation of a Queen, the Minerva of her age. Fontenelle was too much a philosopher and a man of the world, and had himself approached too near to the persons of princes, to be of Mr Conduit's opinion, or to think that the approbation of the most illustrious princess could add dignity to the man who had made the three greatest discoveries yet known, and in whose hands the sciences of Geometry, Optics, and Astronomy, had all taken new forms. If he had been called to write the *Eloge* of the Queen of England, he would, no doubt, have remarked her relish for the conversation of Newton.

On the whole, the *Eloge* on Newton has great merit, and, to be the work of one who was at bottom a Cartesian, is a singular example of candour and impartiality.

[1] Birch's *History of the Royal Society*, vol. III. p. 3.

conveying the action of bodies from one part of the universe to another, and to which the phenomena of light, of heat, of gravitation, are to be ascribed. Here we have his conclusions concerning that polarity or peculiar virtue residing in the opposite sides of the rays of light, which he deduced from the enigmatical phenomena of doubly-refracting crystals. Here, also, the first step is made toward the doctrine of elective attractions or of chemical affinity, and to the notion, that the phenomena of chemistry, as well as of cohesion, depend on the alternate attractions and repulsions existing between the particles of bodies at different distances. The comparison of the gradual transition from repulsion to attraction at those distances, with the positive and negative quantities in algebra, was first suggested here, and is the same idea which the ingenuity of Boscovich afterwards expanded into such a beautiful and complete system. Others who have attempted such flights had ended in mere fiction and romance: it is only for such men as Bacon or Newton to soar beyond the region of poetical fiction, still keeping sight of probability, and alighting again safe on the *terra firma* of philosophic truth.[1]

SECTION IV.

ASTRONOMY.

The time was now come when the world was to be enlightened by a new science, arising out of the comparison of the phenomena of motion as observed in the heavens, with the laws of motion as known on the earth. Physical astronomy was the result of this comparison; a science embracing greater objects, and destined for a higher flight, than any other branch of natural knowledge. It is unnecessary to observe, that it was by Newton that the comparison just referred to was instituted, and the riches of the new science unfolded to mankind.

This young philosopher, already signalized by great discoveries, had scarcely reached the age of twenty-four, when a great public calamity forced him into the situation where the first step in the new science is said to have been suggested; and that, by some of those common appearances in which an ordinary man sees nothing to draw his attention, nor even the man of genius, except at those moments of inspiration when the mind sees farthest into the intellectual world. In 1666, the plague forced him to retire from Cambridge into the country; and, as he sat one day alone, in a garden, musing on the nature of the mysterious force by which the phenomena at the earth's surface are so much regulated, he observed the apples falling spontaneously from the trees, and the thought occurred to him,—since gravity is a tendency not confined to bodies on the very surface of the earth, but reaching to the tops of trees, to the tops of the highest buildings, nay, to the summits of the most lofty mountains, without its intensity or direction suffering any sensible change, why may it not reach to a much greater distance, and even to the moon itself? And, if so, may not the moon be retained in her orbit by gravity, and forced to describe a curve like a projectile at the surface of the earth?[1]

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[1] The optical works of Newton are not often to be found all brought together into one body. The first part of them consists of the papers in the *Philosophical Transactions*, which gave the earliest account of his discoveries, and which have been already referred to. They are in the form of Letters to Oldenburg, the Secretary of the Society, as are also the answers to Hooke and the others who objected to these discoveries; the whole forming a most interesting and valuable series, which Dr Horsley has published in the fourth volume of his edition of Newton's works, under the title of *Letters relating to the Theory of Light and Colours.* The next work, in point of time, consists of the *Lectiones Opticæ*, or the optical lectures which the author delivered at Cambridge. The *Optics*, in three books, is the last and most complete, containing all the reasoning concerning optical phenomena above referred to. The first edition was in 1704; the second, with additions, in 1717. NEWTONI *Opera*, tom. IV. Horsley's edition.

Here another consideration very naturally occurred. Though gravity be not sensibly weakened at the small distances from the surface to which our experiments extend, it may be weakened at greater distances, and at the moon may be greatly diminished. To estimate the quantity of this diminution, Newton appears to have reasoned thus: If the moon be retained in her orbit by her gravitation to the earth, it is probable that the planets are, in like manner, carried round the sun by a power of the same kind with gravity, directed to the centre of that luminary. He proceeded, therefore, to inquire by what law the tendency or gravitation of the planets to the sun must diminish, in order that, describing, as they do, orbits nearly circular round the sun, their times of revolution and their distances may have the relation to one another which they are known to have from observation, or from the third law of Kepler.

This was an investigation which, to most even of the philosophers and mathematicians of that age, would have proved an insurmountable obstacle to their further progress; but Newton was too familiar with the geometry of evanescent or infinitely small quantities, not to discover very soon that the law now referred to would require the force of gravity to diminish exactly as the square of the distance increased. The moon, therefore, being distant from the earth about sixty semidiameters of the earth, the force of gravity at that distance must be reduced to the 3600th part of what it is at the earth's surface. Was the deflection of the moon then from the tangent of her orbit, in a second of time, just the 3600th part of the distance which a heavy body falls in a second at the surface of the earth? This was a question that could be precisely answered, supposing the moon's distance known, not merely in semidiameters of the earth, but in feet, and her angular velocity, or the time of her revolution in her orbit, to be also known.

In this calculation, however, being at a distance from books, he took the common estimation of the earth's circumference that was in use before the measurement of Norwood or of the French Academicians, according to which a degree is held equal to 60 English miles. This being in reality a very erroneous supposition, the result of the calculation did not represent the force as adequate to the supposed effect; whence Newton concluded that some other cause than gravity must act on the moon, and on that account he laid aside, for the time, all further speculation on the subject. It was in the true spirit of philosophy that he so readily gave up an hypothesis, in which he could not but feel some interest, the moment he found it at variance with observation. He was sensible that nothing but the exact coincidence of the things compared could establish the conclusion he meant to deduce, or authorize him to proceed with the superstructure, for which it was to serve as the foundation.

It appears, that it was not till some years after this that his attention was called to the same subject, by a letter from Dr Hooke, proposing, as a question, To determine the line in which a body let fall from a height descends to the ground, taking into consideration the motion of the earth on its axis. This induced him to resume the subject of the moon's motion; and the measure of a degree by Norwood having now furnished more exact data, he found that his calculation gave the precise quantity for the moon's momentary deflection from the tangent of her orbit, which was deduced from astronomical observation. The moon, therefore, has a tendency to descend toward the earth, from the same cause that a stone at its surface has; and if the descent of the stone in a second be diminished in the ratio of 1 to 3600, it will give the quantity by which the moon descends in a second, below the tangent to her orbit· and thus is obtained an experimental proof of the fact, that gravity decreases as the square of the distance increases. He had already found that the times of the planetary revolutions, supposing their orbits to be circular, led to the same conclusion; and he now proceeded, with a view to the solution of Hooke's problem, to inquire what their orbits must be, supposing the centripetal force to be inversely as the square of the distance, and the initial or projectile force to be any whatsoever. On this subject, Pemberton says, he composed (as he calls it) a dozen propositions, which probably were the same with those in the beginning of the *Principia*,—such as the description of equal areas in equal times, about the centre of force, and the ellipticity of the orbits described under the influence of a centripetal force that varied inversely as the squares of the distances.

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[1] Pemberton's *View of Newton's Philosophy*, Pref.

What seems very difficult to be explained is, that after having made trial of his strength, and of the power of the instruments of investigation which he was now in possession of, and had entered by means of them on the noblest and most magnificent field of investigation that was ever yet opened to any of the human race, he again desisted from the pursuit, so that it was not till several years afterwards that the conversation of Dr Halley, who made him a visit at Cambridge, induced him to resume and extend his researches.

He then found, that the three great facts in astronomy, which form the laws of Kepler, gave the most complete evidence to the system of gravitation. The *first* of them, the proportionality of the areas described by the radius vector to the times in which they are described, is the peculiar character of the motions produced by an original impulse impressed on a body, combined with a centripetal force continually urging it to a given centre. The *second* law, that the planets describe ellipses, having the sun in one of the foci, common to them all, coincides with this proposition, that a body under the influence of a centripetal force, varying as the square of the distance inversely, and having any projectile force whatever originally impressed on it, must describe a conic section having one focus in the centre of force, which section, if the projectile force does not exceed a certain limit, will become an ellipse. The *third* law, that the squares of the periodic times are as the cubes of the distances, is a property which belongs to the bodies describing elliptic orbits under the conditions just stated. Thus the three great truths to which the astronomy of the planets had been reduced by Kepler, were all explained in the most satisfactory manner, by the supposition that the planets gravitate to the sun with a force which varies in the inverse ratio of the squares of the distances. It added much to this evidence, that the observations of Cassini had proved the same laws to prevail among the satellites of Jupiter.

But did the principle which appeared thus to unite the great bodies of the universe act only on those bodies? Did it reside merely in their centres, or was it a force common to all the particles of matter? Was it a fact that every particle of matter had a tendency to unite with every other? Or was that tendency directed only to particular centres? It could hardly be doubted that the tendency was common to all the particles of matter. The centres of the great bodies had no properties as mathematical points; they had none but what they derived from the material particles distributed around them. But the question admitted of being brought to a better test than that of such general reasoning as the preceding. The bodies between which this tendency had been observed to take place were all round bodies, and either spherical or nearly so; but whether great or small, they seemed to gravitate toward one another according to the same law. The planets gravitated to the sun, the moon to the earth, the satellites of Jupiter toward Jupiter; and gravity, in all these instances, varied inversely as the squares of the distances. Were the bodies ever so small—were they mere particles—provided only they were round, it was therefore safe to infer, that they would tend to unite with forces inversely as the squares of the distances. It was probable, then, that gravity was the mutual tendency of all the particles of matter toward one another; but this could not be concluded with certainty, till it was found whether great spherical bodies, composed of particles gravitating according to this law, would themselves gravitate according to the same. Perhaps no man of that age but Newton himself was fit to undertake the solution of this problem. His analysis, either in the form of fluxions or in that of prime and ultimate ratios, was able to reduce it to the quadrature of curves; and he then found, no doubt infinitely to his satisfaction, that the law was the same for the sphere as for the particles which compose it; that the gravitation was directed to the centre of the sphere, and was as the quantity of matter contained in it, divided by the square of the distance from its centre. Thus a complete expression was obtained for the law of gravity, involving both the conditions on which it must depend, the quantity of matter in the gravitating bodies, and the distance at which the bodies were placed. There could be no doubt that this tendency was always mutual, as there appeared nowhere any exception to the rule that action and re-action are equal; so that if a stone gravitated to the earth, the earth gravitated equally to the stone; that is to say, the two bodies tended to approach one another with velocities which were inversely as their quantities of matter.[1] There appeared to be no limit to the distance to which this action reached; it was a force that united all the parts of matter to one another; and if it appeared to be particularly directed to certain points, such as the centres of the sun or of the planets, it was only on account of the quantity of matter collected and distributed uniformly round those points, through which, therefore, the force resulting from the composition of all those elements must pass either accurately or nearly.

A remarkable inference was deduced from this view of the planetary motions, giving a deep insight into the constitution of our system in a matter that seems the most recondite, and the farthest beyond the sphere which necessarily circumscribes human knowledge. The quantity of matter, and even the density of the planets, was determined. We have seen how Newton compared the intensity of gravitation at the surface of the earth with its intensity at the moon; and by a computation somewhat similar, he compared the intensity of the earth's gravitation to the sun with the moon's gravitation to the earth, each being measured by the contemporaneous and momentary deflection from a tangent to the small arch of its orbit. A more detailed investigation showed, that the intensity of the central force in different orbits is as the mean distance divided by the square of the periodic time; and the same intensity being also as the quantities of matter divided by the squares of the distances, it follows that these two quotients are equal to one another, and that, therefore, the quantities of matter are as the mean distances divided by the squares of the periodic times. Supposing, therefore, in the instance just mentioned, that the ratio of the mean distance of the sun from the earth to the mean distance of the moon from the earth is given (which it is from astronomical observation); as the ratio of their periodic lines is also known, the ratio of the quantity of matter in the sun to the quantity of matter in the earth, of consequence, is found; and the same holds good for all the planets which have satellites moving round them. Nothing certainly can be more unexpected than that the quantities of matter in bodies so remote should admit of being compared with one another, and with the earth. Hence also their mean densities, or mean specific gravities, became known. For from their distances and the angles they subtended, both known from observation, their magnitudes or cubical contents were easily inferred; and the densities of all bodies are, as their quantities of matter, divided by their magnitude. The *Principia Philosophiæ Naturalis*, which contained all these discoveries, and established the principle of universal gravitation was given to the world in 1687, an era, on that account, for ever memorable in the history of human knowledge.

The principle of gravity, which was thus fully established, and its greatest and most extensive consequences deduced, was not now mentioned for the first time, though for the first time its existence as a fact was ascertained, and the law it observes was discovered. Besides some curious references to weight and gravity, contained in the writings of the ancients, we find something more precise concerning it in the writings of Copernicus, Kepler, and Hooke.

Anaxagoras is said to have held that "the heavens are kept in their place by the rapidity of their revolution, and would fall down if that rapidity were to cease."[1]

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[1] If M and M′ are the masses of two spheres, and x the distance of their centres, $\frac{M+M'}{x^2}$ is the accelerating force with which they tend to unite; but the velocity of the approach of M will be $\frac{M'}{x^2}$, and of M′ $\frac{M}{x^2}$.

Plutarch, in like manner, says the moon is kept from falling by the rapidity of her motion, just as a stone whirled round in a sling is prevented from falling to the ground.[2]

Lucretius, reasoning probably after Democritus, holds, that the atoms would all, from their gravity, have long since united in the centre of the universe, if the universe were not infinite, so as to have no centre.[3]

An observation of Pythagoras, supposed to refer to the doctrine of gravity, though in reality extremely vague, has been abundantly commented on by Gregory and Maclaurin. A musical string, said that philosopher, gives the same sound with another of twice the length, if the latter be straitened by four times the weight that straitens the former; and the gravity of a planet is four times that of another which is at twice the distance. These are the most precise notices, as far as I know, that exist in the writings of the ancients concerning gravity as a force acting on terrestrial bodies, or as extending even to those that are more distant. They are the reveries of ingenious men who had no steady principles deduced from experience and observation to direct their inquiries, and who, even when in their conjectures they hit on the truth, could hardly distinguish it from error.

Copernicus, as might be expected, is considerably more precise. " I do not think," says he, " that gravity is anything but a natural *appetency* of the parts (of the earth) given by the providence of the Supreme Being, that, by uniting together, they may assume the form of a globe. It is probable that this same affection belongs to the sun, the moon, and the fixed stars, which are all of a round form."[4]

The power which Copernicus here speaks of has nothing to do, in his opinion, with the revolutions of the earth or the planets in their different orbits. It is merely intended as an explanation of their globular forms; and the consideration that does the author most credit is that of supposing the force to belong, not to the centre, but to all the parts of the earth.

Kepler, in his immortal work on the *Motions of Mars*, treats of gravity as a force acting naturally from planet to planet, and particularly from the earth to the moon. " If the moon and the earth were not retained by some animal or other equivalent force each in its orbit, the earth would ascend to the moon by a 54th part of the interval between them, while the moon moved over the remaining 53 parts, that is, supposing them both of the same density."[5] This passage is curious, as displaying a singular mixture of knowledge and error on the subject of the planetary motions. The tendency of the earth and moon being mutual, and producing equal quantities of motion in those bodies, bespeaks an accurate knowledge of the nature of that tendency, and of the equality, at least in this instance, between action and re-action. Then, again, the idea of an animal force, or some other equally unintelligible power, being necessary to carry on the circular motion, and to prevent the bodies from moving directly toward each other, is very strange; considering that Kepler knew the inertia of matter, and ought therefore to have understood the nature of centrifugal force, and its power to counteract the mutual gravitations of the two bodies. In this respect the great astronomer, who was laying the foundation of all that is known of the heavens, was not so far advanced as Anaxagoras and Plutarch;—so slow and unequal are the steps by which science advances to perfection. The mutual gravity of the earth and moon is not supposed by Kepler to have any concern in the production of their circular motions; yet he holds the tides to be produced by the gravitation of the waters of the sea toward the moon.[6]

The length to which Galileo advanced in this direction, and the point at which he stopped, are no less curious to be remarked. Though so well acquainted with the nature of gravity on the earth's surface, the object of so many of his researches and discoveries,—and though he conceived it to exist in all the planets, nay, in all the celestial bodies, and to be the cause of their round figure, he did not believe it to be a power that extended from one of those bodies to another. He seems to have thought that gravity was a principle which regulated the domestic economy of each particular body, but had nothing to do with their external relations; so that he censured Kepler for supposing that the phenomena of the tides are produced by the gravitation of the waters of the ocean to the moon.[1]

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[1] Cœlum omne vehementi circuitu constare, alias remissione lapsurum. (DIOG. LAERT. *in Anax.* lib. ii. sect. 12.)
[2] *De Facie in Orbe Lunæ.*
[3] Lib. i. v. 983.
[4] *De Revolutionibus Orbium Cœlestium*, lib. i. cap. ix. p. 17.
[5] On that supposition their quantities of matter would be as their bulks, or as 1 to 53.
[6] *Astronomia Stellæ Martis*, Introd. parag. 8.

Hooke did not stop short in the same unaccountable manner, but made a nearer approach to the truth than any one had yet done. In his attempt to prove the motion of the earth, published in 1674, he lays it down as the principle on which the celestial motions are to be explained, that the heavenly bodies have an attraction or gravitation toward their own centres, which extends to other bodies within the sphere of their activity; and that all bodies would move in straight lines, if some force like this did not act on them continually, and compel them to describe circles, ellipses, or other curve lines. The force of gravity, also, he considered as greatest nearest the body, though the law of its variation he could not determine. These are great advances;—though, from his mention of the sphere of activity, from his considering the force as residing in the centre, and from his ignorance of the law which it observed, it is evident that, besides great vagueness, there was much error in his notions about gravity. Hooke, however, whose candour and uprightness bore no proportion to the strength of his understanding, was disingenuous enough, when Newton had determined that law, to lay claim himself to the discovery.

This is the farthest advance that the knowledge of the cause of the celestial motions had made before the investigations of Newton: it is the precise point at which this knowledge had stopped, having met with a resistance which required a mathematician armed with all the powers of the new analysis to overcome. The doctrine of gravity was yet no more than a conjecture, of the truth or falsehood of which the measurements and reasonings of geometry could alone determine.

Thus, then, we are enabled accurately to perceive in what Newton's discovery consisted. It was in giving the evidence of demonstration to a principle which a few sagacious men had been sufficiently sharp-sighted to see obscurely or inaccurately, and to propose as a mere conjecture. In the history of human knowledge, there is hardly any discovery to which some gradual approaches had not been made before it was completely brought to light. To have found out the means of giving certainty to the thing asserted, or of disproving it entirely, and, when the reality of the principle was found out, to measure its quantity, to ascertain its laws, and to trace their consequences with mathematical precision,—in this consists the great difficulty and the great merit of such a discovery as that which is now before us. In this Newton had no competitor: envy was forced to acknowledge that he had no rival, and consoled itself with supposing that he had no judge.

Of all the physical principles that have yet been made known, there is none so fruitful in consequences as that of gravitation; but the same skill that had directed Newton to the discovery was necessary to enable him to trace its consequences.

The mutual gravitation of all bodies being admitted, it was evident, that while the planets were describing their orbits round the greatest and most powerful body in the system, they must mutually attract one another; and thence, in their revolutions, some irregularities, some deviations from the description of equal areas in equal times, and from the laws of the elliptic motion, might be expected. Such irregularities, however, had not been observed at that time in the motion of any of the planets, except the moon, where some of them were so conspicuous as to have been known to Hipparchus and

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[1] *Dialogo* iv.: Opere, tom. IV. p. 325. Padova, 1744. 4 tom. 4to.

Ptolemy. Newton, therefore, was very naturally led to inquire what the different forces were, which, according to the laws just established, could produce irregularities in the case of the moon's motion. Beside the force of the earth, or rather of the mutual gravitation of the moon and earth, the moon must be acted on by the sun; and the same force which was sufficient to bend the orbit of the earth into an ellipse, could not but have a sensible effect on the orbit of the moon. Here Newton immediately observed, that it is not the whole of the force which the sun exerts on the moon that disturbs her motion round the earth, but only the difference between the force just mentioned and that which the sun exerts on the earth; for it is only that difference that affects the relative positions of the two bodies. To have exact measures of the disturbing forces, he supposed the entire force of the sun on the moon to be resolved into two, of which one always passed through the centre of the earth, and the other was always parallel to the line joining the sun and earth,—consequently, to the direction of the force of the sun on the earth. The former of these forces being directed to the centre of the earth, did not prevent the moon from describing equal areas in equal times round the earth. The effect of it on the whole, however, he showed to be, to diminish the gravity of the moon to the earth by about one 358th part, and to increase her mean distance in the same proportion, and her angular motion by about a 179th.

From the moon thus gravitating to the centre of the earth, not by a force that is altogether inversely as the square of the distance, but by such a force diminished by a small part that varies simply as the distance, it was found, from a very subtile investigation, that the dimensions of the elliptic orbit would not be sensibly changed, but that the orbit itself would be rendered movable, its longer axis having an angular and progressive motion, by which it advanced over a certain arc during each revolution of the moon. This afforded an explanation of the motion of the apsides of the lunar orbit which had been observed to go forward at the rate of 3° 4′ nearly, during the time of the moon's revolution, in respect of the fixed stars.

This was a new proof of the reality of the principle of gravitation, which, however, was rendered less conclusive by the consideration that the exact quantity of the motion of the apsides observed did not come out from the diminution of the moon's gravity as above assigned. There was a sort of cloud, therefore, which hung over this point of the lunar theory, to dissipate which required higher improvements in the calculus than it was given to the inventor himself to accomplish. It was not so with respect to another motion to which the plane of the lunar orbit is subject, a phenomenon which had been long known in consequence of its influence on the eclipses of the sun and moon. This was the retrogradation of the line of nodes, amounting to 3′ 10″ every day. Newton showed that the second of the forces into which the solar action is moved being exerted, not in the plane of the moon's orbit, but in that of the ecliptic, inclined to the former at an angle somewhat greater than five degrees, its effect must be to draw down the moon to the plane of the ecliptic sooner than it would otherwise arrive at it; in consequence of which, the intersection of the two planes would approach, as it were, toward the moon, or move in a direction opposite to that of the moon's motion, or become retrograde. From the quantity of the solar force, and the inclination of the moon's orbit, Newton determined the mean quantity of this retrogradation, as well as the irregularities to which it is subject, and found both to agree very accurately with observation.

Another of the lunar inequalities,—that discovered by Tycho, and called by him the *Variation*, which consists in the alternate acceleration and retardation of the moon in each quarter of her revolution,—was accurately determined from theory, such as it is found by observation; and the same is true as to the annual equation, which had been long confounded with the equation of time. With regard to the other inequalities, it does not appear that Newton attempted an exact determination of them, but satisfied himself with this general truth, that the principle of the sun's disturbing force led to the supposition of inequalities of the same kind with those actually observed, though whether of the same exact quantity it must be difficult to determine. It was reserved, indeed, for a more perfect state of the calculus to explain the whole of those irregularities, and to deduce their precise value from the theory of gravity. Theory has led to the knowledge of many inequalities, which observation alone would have been unable to discover.

While Newton was thus so successfully occupied in tracing the action of gravity among those distant bodies, he did not, it may be supposed, neglect the consideration of its effects on the objects which are nearer us, and particularly on the figure of the earth. We have seen that, even with the limited views and imperfect information which Copernicus possessed on this subject, he ascribed the round figure of the earth and of the planets to the force of gravity residing in the particles of these bodies. Newton, on the other hand, perceived that, in the earth, another force was combined with gravity, and that the figure resulting from that combination could not be exactly spherical. The diurnal revolution of the earth, he knew, must produce a centrifugal force, which would act most powerfully on the parts most distant from the axis. The amount of this centrifugal force is greatest at the equator; and being measured by the momentary recess of any point from the tangent, which was known from the earth's rotation, it could be compared with the force of gravity at the same place, measured in like manner by the descent of a heavy body in the first moment of its fall. When Newton made this comparison, he found that the centrifugal force at the equator is the 289th part of gravity, diminishing continually as the cosine of the latitude, on going from thence toward the poles, where it ceases altogether. From the combination of this force, though small, with the force of gravity, it follows, that the line in which bodies actually gravitate, or the plumb line, cannot tend exactly to the earth's centre, and that a true horizontal line, such as is drawn by levelling, if continued from either pole, in the plane of a meridian all round the earth, would not be a circle, but an ellipse, having its greatest axis in the plane of the equator, and its least in the direction of the axis of the earth's rotation. Now, the surface of the ocean itself actually traces this level as it extends from the equator to either pole. The terraqueous mass which we call the globe must therefore be what geometers call an oblate spheroid, or a solid generated by the revolution of the elliptic meridian about its shorter axis.

In order to determine the proportion of the axes of this spheroid, a problem, it will readily be believed, of no ordinary difficulty, Newton conceived, that if the waters at the pole and at the equator were to communicate by a canal through the interior of the earth, one branch reaching from the pole to the centre, and the other at right angles to it from the centre to the circumference of the equator, the water in this canal must be *in equilibrio*, or the weight of fluid in the one branch just equal to that in the other. Including, then, the consideration of the centrifugal force which acted on one of the branches but not on the other, and considering, too, that the figure of the mass being no longer a sphere, the attraction must not be supposed to be directed to the centre, but must be considered as the result of the action of all the particles of the spheroid on the fluid in the canals,—by a very subtile process of reasoning, Newton found that the longer of the two canals must be to the shorter as 230 to 229. This, therefore, is the ratio of the radius of the equator to the polar semiaxis, their difference amounting, according to the dimensions then assigned to the earth, to about $17\frac{1}{10}$ English miles. In this investigation the earth is understood to be homogeneous, or everywhere of the same density.

It is very remarkable, that though the ingenious and profound reasoning on which this conclusion rests is not entirely above objection, and assumes some things without sufficient proof, yet, when these defects were corrected in the new investigations of Maclaurin and Clairaut, the conclusion, supposing the earth homogeneous, remained exactly the same. The sagacity of Newton, like the *Genius* of Socrates, seemed sometimes to inspire him with wisdom from an invisible source. By a profound study of nature, her laws, her analogies, and her resources, he seems to have acquired the same sort of *tact* or *feeling* in matters of science, that experienced engineers and other artists sometimes acquire in matters of practice, by which they are often directed right, when they can scarcely describe in words the principle on which they proceed.

From the figure of the earth thus determined, he showed that the intensity of gravity at any point of the surface is inversely as the distance of that point from the centre; and its increase, therefore, on going from the equator to the poles, is as the square of the sine of the latitude, the same ratio in which the degrees of the meridian increase.[1] As the intensity of gravity diminished on going from the poles to the equator, or from the higher to the lower latitudes, it followed that a pendulum of a given length would vibrate slower when carried from Europe into the torrid zone. The observations of the two French astronomers Varin and De Hayes, made at Cayenne and Martinique, had already confirmed this conclusion.

The problem which Newton had thus resolved enabled him to resolve one of still greater difficulty. The precession, that is, the retrogradation, of the equinoctial points, had been long known to astronomers; its rate had been measured by a comparison of ancient and modern observations, and found to amount nearly to 50″ annually, so as to complete an entire revolution of the heavens in 25,920 years. Nothing seemed more difficult to explain than this phenomenon, and no idea of assigning a physical or mechanical cause for it had yet occurred, I believe, to the boldest and most theoretical astronomer. The honour of assigning the true cause was reserved for the most cautious of philosophers. He was directed to this by a certain analogy observed between the precession of the equinoxes and the retrogradation of the moon's nodes, a phenomenon to which his calculus had been already successfully applied. The spheroidal shell or ring of matter which surrounds the earth, as we have just seen, in the direction of the equator, being one half above the plane of the ecliptic and the other half below, is subjected to the action of the solar force, the tendency of which is to make this ring turn on the line of its intersection with the ecliptic, so as ultimately to coincide with the plane of that circle. This, accordingly, would have happened long since, if the earth had not revolved on its axis. The effect of the rotation of the spheroidal ring from west to east, at the same time that it is drawn down toward the plane of the ecliptic, is to preserve the inclination of these two planes unchanged, but to make their intersection move in a direction opposite to that of the diurnal rotation, that is, from east to west, or contrary to the order of the signs.

The calculus in its result justified this general conclusion: 10″ appeared the part of the effect due to the moon's attraction, 40″ to the attraction of the sun; and I know not if there be any thing respecting the constitution of our system, in which this great philosopher gave a stronger proof of his sagacity and penetration, than in the explanation of this phenomenon. The truth, however, is, that his data for resolving the problem were in some degree imperfect, all the circumstances were not included, and some were erroneously applied, yet the great principle and scope of the solution were right, and the approximation very near to the truth. "Il a été bien servi par son génie," says the eloquent and judicious historian of astronomy; "l'inspiration de cette faculté divine lui a fait appercevoir des déterminations qui n'étoient pas encore accessibles; soit qu'il eût des preuves qu'il a supprimées, *soit qu'il eût dans l'esprit une sorte d'estime, une espece de balance pour apprécier certaines vérités, en pesant les vérités prochaines, et jugeant les unes par les autres*."[2]

It was reserved for a more advanced condition of the new analysis to give to the solution of this problem all the accuracy of which it is susceptible. It is a part, and a distinguishing part, of the glory of this system, that it was susceptible of more perfection than it received from the hands of the author; and that the century and a half which has nearly elapsed since the first discovery of it has been continually adding to its perfection. This character belongs to a system which has truth and nature for its basis, and had not been exhibited in any of the physical theories that had yet appeared in the world.

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[1] *Princip.* lib. iii. prop. 20.

[2] BAILLY, *Histoire de l'Astronomie Moderne*, tome II. livre xii. sect. 28.

The doctrines of Plato and Aristotle were never more perfect than when they came from the hands of their respective authors; and a legion of commentators, with all their efforts, did nothing but run round perpetually in the same circle. Even Descartes, though he had recourse to physical principles, and tried to fix his system on a firmer basis than the mere abstractions of the mind, left behind him a work which not only could not be improved, but was such, that every addition attempted to be made destroyed the equilibrium of the mass, and pulled away the part to which it was intended that it should be attached. The philosophy of Newton has proved susceptible of continual improvement; its theories have explained facts quite unknown to the author of it; and the exertions of Lagrange and Laplace, at the distance of a hundred years, have perfected a work which it was not for any of the human race to begin and to complete.

Newton next turned his attention to the phenomena of the Tides, the dependence of which on the moon, and in part also on the sun, was sufficiently obvious even from common observation. That the moon is the prime ruler of the tide, is evident from the fact, that the high-water, at any given place, occurs always nearly at the moment when the moon is on the same meridian, and that the retardation of the tide from day to day is the same with the retardation of the moon in her diurnal revolution. That the sun is also concerned in the production of the tides is evident from this, that the highest tides happen when the sun, the moon, and the earth are all three in the same straight line; and that the lowest, or neap tides, happen when the lines drawn from the sun and moon to the earth make right angles with one another. The eye of Newton, accustomed to generalize and to penetrate beyond the surface of things, saw that the waters of the sea revolving with the earth are nearly in the condition of a satellite revolving about its primary, and are liable to the same kind of disturbance from the attraction of a third body. The fact in the history of the tides which seems most difficult to be explained, received, on this supposition, a very easy solution. It is known that high-water always takes place in the hemisphere where the moon is, and in the opposite hemisphere where the moon is not, nearly at the same time. This seems, at first sight, very unlike an effect of the moon's attraction; for, though the water in the hemisphere where the moon is, and which therefore is nearest the moon, may be drawn up toward that body, the same ought not to happen in the opposite hemisphere, where the earth's surface is most distant from the moon. But if the action of the moon disturb the equilibrium of the ocean, just as the action of one planet disturbs the motion of a satellite moving round another, it is exactly what might be expected. It had been shown that the moon, in conjunction with the sun, has her gravitation to the earth diminished, and when in opposition to the sun has it diminished very nearly by the same quantity. The reason is, that at the conjunction, or the new moon, the moon is drawn to the sun more than the earth is; and that, at the opposition, or full moon, the earth is drawn toward the sun more than the moon nearly by the same quantity: the relative motion of the two bodies is therefore affected the same way in both cases, and the gravity of the moon to the earth, or her tendency to descend toward it, is in both cases lessened.

It is plain that the action of the moon on the waters of the ocean must be regulated by the same principle. In the hemisphere where the moon is, the water is more drawn toward the moon than the mass of the earth is, and its gravity being lessened, the columns toward the middle of the hemisphere lengthen, in consequence of the pressure of the columns which are at a distance from the middle point, of which the weight is less diminished, and toward the horizon must even be increased. In the opposite hemisphere, again, the mass of the earth is more drawn to the moon than the waters of that hemisphere, and their relative tendencies are changed in the same direction, and nearly by the same quantity. If the action of the moon on all the parts of the earth, both sea and land, were the same, no tide whatever would be produced.

Thus, the same analysis of the force of gravity which explained the inequalities of the moon, were shown by Newton to explain those inequalities in the elevation of the waters of the ocean to which we give the name of tides. On the principle also explained in this analysis it is that the attraction of the sun and moon conspire to elevate the waters of the ocean, whether these luminaries be in opposition or conjunction. In both cases the solar and lunar tides are added together, and the tide actually observed is their sum. At the quadratures, or the first and third quarters, these two sides are opposed to one another, the high water of the lunar tide coinciding with the low water of the solar, and conversely, so that the tide actually observed is the difference of the two.

The other phenomena of the tides were explained in a manner no less satisfactory; and it only remained to inquire, whether the quantity of the solar and lunar forces were adequate to the effect thus ascribed to them. The lunar force there were yet no data for measuring; but a measure of the solar force, as it acts on the moon, had been obtained, and it had been shown that in its mean quantity it amounted to $\frac{1}{178}$ of the force which retains the moon in her orbit. This last is $\frac{1}{3600}$ of the force of gravity at the earth's surface; and, therefore, the force with which the sun disturbs the moon's motion is $\frac{1}{178} \times \frac{1}{3600}$ of gravity at the earth's surface. This is the solar disturbing force on the moon when distant sixty semidiameters from the earth's centre; but on a body only one semidiameter distant from that centre, that is, on the water of the ocean, the disturbing force would be sixty times less, and thus is found to be no more than $\frac{1}{38448000}$ of gravity at the earth's surface.

Now, this being the mean force of the sun, is that by which he acts on the waters, 90 degrees distant from the point to which he is vertical, where it is added to the force of gravity, and tends to increase the weight and lower the level of the waters. At the point where the sun is vertical, the force to raise the water is about double of this; and, therefore, the whole force tending to raise the level of the high above that of the low water is three times the preceding, or about the $\frac{1}{12816000}$ of gravity. Small as this force is, when it is applied to every particle of the ocean, it is capable of producing a sensible effect. The manner in which Newton estimates this effect can only be considered as affording an approximation to the truth. In treating of the figure of the earth, he had shown that the centrifugal force, amounting to $\frac{1}{289}$ of gravity, was able to raise the level of the ocean more than seventeen miles, or, more exactly, 85,472 French feet. Hence, making the effect proportional to the forces, the elevation of the waters produced by the solar force will come out 1·92 foot.

But, from the comparison of the neap and spring tides, that is, of the difference and the sum of the lunar and solar forces, it appears that the force of the moon is to that of the sun as 4·48 to 1. As the solar force raises the tide 1·92 foot, the lunar will raise it 8·63 feet; so that the two together will produce a tide of 10½ French feet,[1] which agrees not ill with what is observed in the open sea, at a distance from land.

The calculus of Newton stopped not here. From the force that the moon exerts on the waters of the ocean, he found the quantity of matter in the moon to that in the earth as 1 to 39·78, or, in round numbers, as 1 to 40. He also found the density of the moon to the density of the earth as 11 to 9.

Subsequent investigations, as we shall have occasion to remark, have shown that much was yet wanting to a complete theory of the tides; and that even after Maclaurin, Bernoulli, and Euler[2] had added their efforts to those of Newton, there remained enough to give full employment to the calculus of Laplace. As an original deduction, and as a first approximation, that of which I have now given an account will be for ever memorable.

The motion of Comets yet remained to be discussed. They had only lately been acknowledged to belong to the heavens, and to be placed beyond the region of the earth's atmosphere; but with regard to their motion, astronomers were not agreed. Kepler believed them to move in straight lines; Cassini thought they moved in the planes of great circles, but with little curvature. Hevelius had come much nearer the truth: he had shown the curvature of their paths to be different in different parts, and to be greatest when they were nearest the sun; and a parabola having its vertex in that point seemed to him to be the line in which the comet moved. Newton, convinced of the universality of the principle of gravitation, had no doubt that the orbit of the comet must be a conic section, having the sun in one of its foci, and might either be an ellipse, a parabola, or even an hyperbola, according to the relation between the force of projection and the force tending to the centre. As the eccentricity of the orbit on every supposition must be great, the portion of it that fell within our view could not differ much from a parabola; a circumstance which rendered the calculation of the comet's place, when the position of the orbit was once ascertained, more easy than in the case of the planets. Thus far theory proceeded; and observation must then determine with what degree of accuracy this theory represented the phenomena. From three observations of the comet the position of the orbit could be determined, though the geometric problem was one of great difficulty. Newton gave a solution of it; and it was by this that his theory was to be brought to the test of experiment. If the orbit thus determined was not the true one, the places of the comet calculated on the supposition that it was, and that it described equal areas in equal times about the sun, could not agree with the places actually observed. Newton showed, by the example of the remarkable comet then visible, (1680) that this agreement was as great as could reasonably be expected; thus adding another proof to the number of those already brought to support the principle of universal gravitation. The comets descend into our system from all different quarters in the heavens, and therefore the proofs that they afforded went to show, that the action of gravity was confined to no particular region of the heavens.

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[1] Newtoni *Princip.* lib. iii. prop. 36, 37.

[2] See the solutions of these three mathematicians in the Commentary of Le Seur and Jacquier on the third book of the *Principia.*

Thus far Newton proceeded in ascertaining the existence, and in tracing the effects, of the principle of gravitation, and had done so with a success of which there had been no instance in the history of human knowledge. At the same time that it was the most successful, it was the most difficult research that had yet been undertaken. The reasonings upward from the facts to the general principle, and again down from that principle to its effects, both required the application of a mathematical analysis which was but newly invented; and Newton had not only the difficulties of the investigation to encounter, but the instrument to invent, without which the investigation could not have been conducted. Every one who considers all this will readily join in the sentiment with which Bailly closes a eulogy as just as it is eloquent: "*Si, comme Platon l'a pensé, il existoit dans la nature une échelle d'êtres et de substances intelligentes jusqu'à l'Etre Suprême, l'espece humaine, défendant ses droits, auroit une foule de grands hommes à présenter ; mais Newton, suivi de ses vérités pures, montreroit le plus haut degré de force de l'esprit humain, et suffiroit seul pour lui assigner sa vraie place.*"[1]

Though the creative power of genius was never more clearly evinced than in the discoveries of this great philosopher, yet the influence of circumstances, always extensive and irresistible in human affairs, can readily be traced. The condition of knowledge at the time when Newton appeared was favourable to great exertions; it was a moment when things might be said to be prepared for a revolution in the mathematical and physical sciences. The genius of Copernicus had unfolded the true system of the world; and Galileo had shown its excellence, and established it by arguments, the force of which were generally acknowledged. Kepler had done still more, having, by an admirable effort of generalization, reduced the facts concerning the planetary motions to three general laws. Cassini's observations had also extended the third of these laws to the satellites of Jupiter, showing that the squares of their periodic times were as the cubes of their distances from the centre of the body round which they revolved. The imaginary apparatus of cycles and epicycles,—the immobility of the earth,—the supposed essential distinction between celestial and terrestrial substances, those insuperable obstacles to real knowledge, which the prejudice of the ancients had established as physical truths, were entirely removed; and Bacon had taught the true laws of philosophizing, and pointed out the genuine method of extracting knowledge from experiment and observation. The leading principles of mechanics were established; and it was no unimportant circumstance, that the *Vortices* of Descartes had exhausted one of the sources of error, most seducing on account of its simplicity.

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[1] *Histoire de l'Astronomie Moderne*, tome II. livre xii. sect. 49.

All this had been done when the genius of Newton arose upon the earth. Never till now had there been set before any of the human race so brilliant a career to run, or so noble a prize to be obtained. In the progress of knowledge, a moment had arrived more favourable to the development of talent than any other, either later or earlier, and in which it might produce the greatest possible effect. But, let it not be supposed, while I thus admit the influence of external circumstances on the exertions of intellectual power, that I am lessening the merit of this last, or taking any thing from the admiration that is due to it. I am, in truth, only distinguishing between what it is possible and what it is impossible for the human mind to effect. With all the aid that circumstances could give, it required the highest degree of intellectual power to accomplish what Newton performed. We have here a memorable, perhaps a singular instance, of the highest degree of intellectual power, united to the most favourable condition of things for its exertion. Though Newton's situation was more favourable than that of the men of science who had gone before him, it was not more so than that of those men who pursued the same objects at the same time with himself, placed in a situation equally favourable.

When one considers the splendour of Newton's discoveries, the beauty, the simplicity, and grandeur of the system they unfolded, and the demonstrative evidence by which that system was supported, one could hardly doubt that, to be received, it required only to be made known, and that the establishment of the Newtonian philosophy all over Europe would very quickly have followed the publication of it. In drawing this conclusion, however, we should make much too small an allowance for the influence of received opinion, and the resistance that mere habit is able, for a time, to oppose to the strongest evidence. The Cartesian system of vortices had many followers in all the countries of Europe, and particularly in France. In the universities of England, though the Aristotelian Physics had made an obstinate resistance, they had been supplanted by the Cartesian, which became firmly established about the time when their foundation began to be sapped by the general progress of science, and particularly by the discoveries of Newton. For more than thirty years after the publication of those discoveries, the system of vortices kept its ground; and a translation from the French into Latin of the *Physics* of Rohault, a work entirely Cartesian, continued at Cambridge to be the text for philosophical instruction. About the year 1718, a new and more elegant translation of the same book was published by Dr Samuel Clarke, with the addition of notes, in which that profound and ingenious writer explained the views of Newton on the principal objects of discussion; so that the notes contained *virtually* a refutation of the text: they did so, however, only virtually, all appearance of argument and controversy being carefully avoided. Whether this escaped the notice of the learned Doctors or not, is uncertain; but the new translation, from its better Latinity, and the name of the editor, was readily admitted to all the academical honours which the old one had enjoyed. Thus, the stratagem of Dr Clarke completely succeeded; the tutor might prelect from the text, but the pupil would sometimes look into the notes; and error is never so sure of being exposed as when the truth is placed close to it, side by side, without any thing to alarm prejudice, or awaken from its lethargy the dread of innovation. Thus, therefore, the *Newtonian* philosophy first entered the University of Cambridge under the protection of the *Cartesian.*[1]

If such were the obstacles to its progress that the new philosophy experienced in a country that was proud of having given birth to its author, we must expect it to advance very slowly indeed among foreign nations. In France, we find the first astronomers and mathematicians, such men as Cassini and Maraldi, quite unacquainted with it, and employed in calculating the paths of the comets they were observing, on hypotheses the most unfounded and imaginary; long after Halley, following the principles of Newton, had computed tables from which the motions of all the comets that ever had appeared, or ever could appear, might be easily deduced. Fontenelle, with great talents and enlarged views, and, as one may say, officially informed of the progress of science all over Europe, continued a Cartesian to the end of his days. Mairan in his youth was a zealous defender of the vortices, though he became afterwards one of the most strenuous supporters of the doctrine of gravitation.

A Memoir of the Chevalier Louville, among those of the Academy of Sciences for 1720, is the first in that collection, and, I believe, the first published in France, where the elliptic motion of the planets is supposed to be produced by the combination of two forces, one projectile and the other centripetal. Maupertuis soon after went much farther: in his elegant and philosophic treatise, *Figure des Astres*, published about 1730, he not only admitted the existence of attraction as a fact, but even defended it, when considered as an universal property of body, against the reproach of being a metaphysical absurdity. These were considerable advances, but they were made slowly; and it was true, as Voltaire afterwards remarked, that though the author of the *Principia* survived the publication of that great work nearly forty years, he had not, at the time of his death, twenty followers out of England.

We should do wrong, however, to attribute this slow conversion of the philosophic world entirely to prejudice, inertness, or apathy. The evidence of the Newtonian philosophy was of a nature to require time in order to make an impression. It implied an application of mathematical reasoning which was often difficult: the doctrine of prime and ultimate ratios was new to most readers, and could be familiar only to those who had studied the infinitesimal analysis.

The principle of gravitation itself was considered as difficult to be admitted. When presented indeed as a mere fact, like the weight of bodies at the earth's surface, or their tendency to fall to the ground, it was free from objection; and it was in this light only that Newton wished it to be considered.[2] But though this appears to be the sound and philosophical view of the subject, there has always appeared a strong desire in those who speculated concerning gravitation to go farther, and to inquire into the cause of what, as a mere fact, they were sufficiently disposed to admit. If you said that you had no explanation to give, and were only desirous of having the fact admitted, they alleged that this was an unsatisfactory proceeding,—that it was admitting the doctrine of *occult causes*,—that it amounted to the assertion, that bodies acted in places where they were not,—a proposition that, metaphysically considered, was undoubtedly absurd. The desire to explain gravitation is indeed so natural, that Newton himself felt its force, and has thrown out, at the end of his *Optics*, some curious conjectures concerning this general affection of body, and the nature of that elastic ether to which he thought that it was perhaps to be ascribed. "Is not this medium (the ether) much rarer within the dense bodies of the sun, stars, and planets, than in the empty celestial spaces between them? And, in passing from them to great distances, does it not grow denser and denser perpetually, and thereby cause the gravity of those great bodies to one another, every body endeavouring to go from the denser parts of the medium to the rarer?"[1]

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[1] The Universities of St Andrews and Edinburgh were, I believe, the first in Britain where the Newtonian philosophy was made the subject of the academical prelections. For this distinction they are indebted to James and David Gregory, the first in some respects the rival, but both the friends of Newton. Whiston bewails in the anguish of his heart the difference in this respect between those universities and his own. David Gregory taught in Edinburgh for several years prior to 1690, when he removed to Oxford; and Whiston says, "He had already caused several of his scholars to keep acts, as we call them, upon several branches of the Newtonian philosophy, while we at Cambridge (poor wretches) were ignominiously studying the fictitious hypotheses of the Cartesian." (WHISTON's *Memoirs of his own Life.*) I do not, however, mean to say, that from this date the Cartesian philosophy was expelled from those universities. The *Physics* of Rohault were still in use as a text, at least occasionally, to a much later period than this; and a great deal, no doubt, depended on the character of the individual professors. Keill introduced the Newtonian philosophy in his lectures at Oxford in 1697; but the instructions of the tutors, which constitute the real and efficient system of the university, were not cast in that mould till long afterwards. The publication of S'Gravesande's *Elements* proves that the Newtonian philosophy was taught in the Dutch universities before the date of 1720.

[2] "*Vocem attractionis hic generaliter usurpo pro corporum conatu quocunque accedendi ad invicem; sive conatus iste fiat ab actione corporum, vel se mutuo petentium, vel per spiritus emissos se invicem agitantium; sive is ab actione ætheris, aut aeris, mediive cujuscunque, seu corporei seu incorporei, oriatur, corpora innatantia in se invicem utcunque impellentis.*" (*Principia Math.* lib. i. schol. ad finem prop. 69.)

Notwithstanding the highest respect for the author of these conjectures, I cannot find any thing like a satisfactory explanation of gravity in the existence of this elastic ether. It is very true that an elastic fluid, of which the density followed the inverse ratio of the distance from a given point, would urge the bodies immersed in it, and impervious to it, toward that point with forces inversely as the squares of the distances from it; but what could maintain an elastic fluid in this condition, or with its density varying according to this law, is a thing as inexplicable as the gravity which it was meant to explain. The nature of an elastic fluid must be, in the absence of all inequality of pressure, to become everywhere of the same density. If the causes that produce so marked and so general a deviation from this rule be not assigned, we can only be said to have substituted one difficulty for another.

A different view of the matter was taken by some of the disciples and friends of Newton, but which certainly did not lead to any thing more satisfactory. That philosopher himself had always expressed his decided opinion that gravity could not be considered as a property of matter;[2] but Mr Cotes, in the preface to the second edition of the *Principia*, maintains that gravity is a property which we have the same right to ascribe to matter, that we have to ascribe to it extension, impenetrability, or any other property. This is said to have been inserted without the knowledge of Newton,—a freedom which it is difficult to conceive that any man could use with the author of the *Principia.* However that be, it is certain that these difficulties have been always felt, and had their share in retarding the progress of the philosophy to which they seemed to be inseparably attached.

There were other arguments of a less abstruse nature, and more immediately connected with experiment, which, for a time, resisted the progress of the Newtonian philosophy, though they contributed, in the end, very materially to its advancement. Nothing, indeed, is so hostile to the interests of truth, as facts inaccurately observed; of which we have a remarkable example in the measurement of an arch of the meridian across France, from Amiens to Perpignan, though so large as to comprehend about seven degrees, and though executed by Cassini, one of the first astronomers in Europe. According to that measurement, the degrees seemed to diminish on going from south to north, each being less by about an 800th part than that which immediately preceded it toward the south. From this result, which is entirely erroneous, the conclusion first deduced was correct, the error in the reasoning, by a very singular coincidence, having corrected the error in the data from which it was deduced. Fontenelle argued that, as the degrees diminished in length on going toward the poles, the meridian must be less than the circumference of the equator, and the earth of course swelled out in the plane of that circle, agreeably to the facts that had been observed concerning the retardation of the pendulum when carried to the south. This, however, was the direct contrary of the conclusion which ought to have been drawn, as was soon perceived by Cassini and by Fontenelle himself. The degrees growing less as they approached the pole, was an indication of the curvature growing greater, or of the longer axis of the meridian being the line that passed through the poles, and that coincided with the axis of the earth. The figure of the earth must, therefore, be that of an oblong spheroid, or one formed by the revolution of an ellipsis about its longer axis. This conclusion seemed to be strengthened by the prolongation of the meridian from Amiens northward to Dunkirk in 1713, as the same diminution was observed; the medium length of the degree between Paris and Dunkirk being 56970 toises, no less than 137 less than the mean of the degrees toward the south.[1] All this seemed quite inconsistent with the observations on the pendulum, as well as with the conclusions which Newton had deduced from the theory of gravity. The Academy of Sciences was thus greatly perplexed, and uncertain to what side to incline. In these circumstances, J. Cassini, whose errors were the cause of all the difficulty, had the merit of suggesting the only means by which the question concerning the figure of the earth was likely to receive a satisfactory solution,—the measurement of two degrees, the one under the equator, and the other as near to the pole as the nature of the thing would admit. But it was not till considerably beyond the limits of the period of which I am now treating, that these measures were executed, and that the increase of the degrees toward the poles, or the oblateness of the earth's figure, was completely ascertained. Cassini, on resuming his own operations, discovered, and candidly acknowledged, the errors in his first measurement; and thus the objections which had arisen in this quarter against the theory of gravity became irresistible arguments in its favour. This subject will occupy much of our attention in the history of the *second period*, till which the establishment of the Newtonian philosophy on the Continent cannot be said to have been accomplished.

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[1] *Optics*, query 21, at the end of the third book.

[2] The passages quoted sufficiently prove that Newton did not consider gravity as a property inherent in matter. The following passage in one of his letters to Dr Bentley is still more explicit: "It is inconceivable that inanimate brute matter should, without the mediation of something else, which is not material, operate upon and affect other matter without mutual contact; as it must do, if gravitation, in the sense of Epicurus, be essential and inherent in it...That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a vacuum, without the mediation of any thing else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it." (NEWTONI *Opera*, tom. IV. p. 438. Horsley's edit.) On this passage I cannot help remarking, that it is not quite clear in what manner the interposition of a material substance can convey the action of distant bodies to one another. In the case of percussion or pressure, this is indeed very intelligible, but it is by no means so in the case of attraction. If two particles of matter, at opposite extremities of the diameter of the earth, attract one another, this effect is just as little intelligible, and the *modus agendi* is just as mysterious, on the supposition that the whole globe of the earth is interposed, as on that of nothing whatever being interposed, or of a complete vacuum existing between them. It is not enough that each particle attracts that in contact with it; it must attract the particles that are distant, and the intervention of particles between them does not render this at all more intelligible.

In addition to these discoveries in physical astronomy, this period affords several on the descriptive parts of the science, of which, however, I can only mention one, as far too important to be passed over in the most general outline. It regards the apparent motion in the fixed stars, known by the name of the Aberration, and is the discovery of Dr Bradley, one of the most distinguished astronomers of whom England has to boast. Bradley and his friend Molyneux, in the end of the year 1725,[2] were occupied in searching for the parallax of the fixed stars by means of a zenith sector, constructed by Graham, the most skilful instrument maker of that period. The sector was erected at Kew; it was of great radius, and furnished with a telescope twenty-four feet in length, with which they proposed to observe the transits of stars near the zenith, according to a method that was first suggested by Hooke, and pursued by him so far as to induce him to think that he had actually discovered the parallax of γ *Draconis*, the bright star in the head of the dragon, on which he made his observations. They began their observations of the transits of the same star on the 3d of December, when the distance from the zenith at which it passed was carefully marked. By the observations of the subsequent days the star seemed to be moving to the south; and about the beginning of March in the following year, it had got 20″ to the south, and was then nearly stationary. In the beginning of June it had come back to the same situation where it was first observed, and from thence it continued its motion northward till September, when it was about 20″ north of the point where it was first seen, its whole change of declination having amounted to 40″.

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[1] *Mémoires de l'Académie des Sciences*, 1718, p. 245.

[2] *Phil. Trans.* vol. XXXV. p. 697.

This motion occasioned a good deal of surprise to the two observers, as it lay the contrary way to what it would have done if it had proceeded from the parallax of the star. The repetition of the observations, however, confirmed their accuracy; and they were afterwards pursued by Dr Bradley, with another sector constructed also by Graham, of a less radius, but still of one sufficiently great to measure a star's zenith distance to half a second. It embraced a larger arch, and admitted of the observations being extended to stars that passed at a more considerable distance from the zenith.

Even with this addition the observations did not put Bradley in possession of the complete fact, as they only gave the motion of each star in declination, without giving information about what change might be produced in its right ascension.

Had the whole fact, that is, the motion in right ascension as well as in declination, been given from observation, it could not have been long before the cause was discovered. With such information, however, as Dr Bradley had, that discovery is certainly to be regarded as a great effort of sagacity. He has not told us the steps by which he was led to it; only we see that, by the method of exclusion, he had been careful to narrow the field of hypothesis, and had assured himself that the phenomenon was not produced by any nutation of the earth's axis,—by any change in the direction of the plumb-line, or by refraction of any kind. All these causes being rejected, it occurred to him that the appearances might arise from the progressive motion of light combined with the motion of the earth in its orbit. He reasoned somewhat in this manner. If the earth were at rest, it is plain that a telescope, to admit a ray of light coming from a star to pass along its axis, must be directed to the star itself. But, if the earth, and of course the telescope, be in motion, it must be inclined forward, so as to be in the diagonal of a parallelogram, the sides of which represent the motion of the earth and the motion of light; or in the direction of those motions, and in the ratio of their velocities. It is with the telescope just as with the vane at the mast-head of a ship: when the ship is at anchor, the vane takes exactly the direction of the wind; when the ship is under weigh, it places itself in the diagonal of a parallelogram, of which one side represents the velocity of the ship, and the other the velocity of the wind. If, instead of the vane, we conceive a hollow tube, movable in the same manner, the case will become more exactly parallel to that of the telescope. The tube will take such a position that the wind may blow through it without striking against the sides, and its axis will then be the diagonal of the parallelogram just referred to.

The telescope, therefore, through which a star is viewed, and by the axis of which its position star is determined, must make an angle with the straight line drawn to the star, except when the earth moves directly upon the star, or directly from it. Hence it follows, that if the star be in the pole of the ecliptic, the telescope must be pointed forward, in the direction of the earth's motion, always by the same angle; so that the star would be seen out of its true place by that angle, and would appear to describe a circle round the pole of the ecliptic, the radius of which subtended, at the earth, an angle, of which the sine is to unity as the velocity of the earth to the velocity of light. If the star be anywhere between the plane of the ecliptic and the pole, its apparent path will be an ellipse, the longer axis of which is the same with the diameter of the former circle, and the shorter equal to the same quantity, multiplied by the sine of the star's latitude. If the star be in the plane of the ecliptic, this shorter axis vanishes, and the apparent path of the star is a straight line, equal to the axis just mentioned.

Bradley saw that Roemer's observation concerning the time that light takes to go from the sun to the earth gave a ready expression for the velocity of light compared with that of the earth. The proportion, however, which he assumed as best suited to his observations was somewhat different; it was that of 10313 to 1, which made the radius of the circle of aberration 20″, and the transverse axis of the ellipse in every case, or the whole change of position, 40″. It was the shorter axis which Bradley had actually observed in the case of γ *Draconis*, that star being very near the solstitial colure, so that its changes of declination and of latitude are almost the same. In order to show the truth of his theory, he computed the aberration of different stars, and, on comparing the results with his observations, the coincidence appeared almost perfect, so that no doubt remained concerning the truth of the principle on which he had founded his calculations. He did not explain the rules themselves: Clairaut published the first investigation of these in the *Memoirs of the Academy of Sciences* for 1737. Simpson also gave a demonstration of them in his *Essays*, published in 1740.

It has been remarked, that the velocity of light, as assumed by Bradley, did not exactly agree with that which Roemer had assigned: supposing the total amount of the aberration 40½″, it gave the time that light takes to come from the sun to the earth 8′ 13″; but it is proper to add, that since the time of this astronomer, the velocity of light deduced from the eclipses of Jupiter's satellites has been found exactly the same.

It is remarkable that the phenomenon thus discovered by Bradley and Molyneux, when in search of the parallax of the fixed stars, is in reality as convincing a proof of the earth's motion in its orbit as the discovery of that parallax would have been. It seems, indeed, as satisfactory as any evidence that can be desired. One only regrets, in reflecting on this discovery, that the phenomenon of the aberration was not foreseen, and that, after being predicted from theory, it had been ascertained from observation. As the matter stands, however, the discovery both of the fact and the theory is highly creditable to its author.

In the imperfect outline which I have now sketched of one of the most interesting periods in the history of human knowledge, much has been omitted, and many great characters passed over, lost, as it were, in the splendour of the two great luminaries which marked this epocha. Newton and Leibnitz are so distinguished from the rest even of the scientific world, that we can only compare them with one another, though, in fact, no two intellectual characters, who both reached the highest degree of excellence, were ever more dissimilar.

For the variety of his genius, and the extent of his research, Leibnitz is perhaps altogether unrivalled. A lawyer, an historian, an antiquary, a poet, and a philologist,—a mathematician, a metaphysician, a theologian, and, I will add, a geologer, he has in all these characters produced works of great merit, and in some of them of the highest excellence. It is rare that original genius has so little of a peculiar direction, or is disposed to scatter its efforts over so wide a field. Though a man of great inventive powers, he occupied much of his time in works of mere labour and erudition, where there was nothing to invent, and not much of importance to discover. Of his inventive powers as a mathematician we have already spoken; as a metaphysician, his acuteness and depth are universally admitted: but metaphysics is a science in which there are few discoveries to be made; and the man who searches in it for novelty, is more likely to find what is imaginary than what is real. The notion of the *Monads*, those unextended units, or simple essences, of which, according to this philosopher, all things corporeal and spiritual, material or intellectual, are formed, will be readily allowed to have more in it of novelty than truth. The *pre-established harmony* between the body and the mind, by which two substances incapable of acting on one another are so nicely adjusted from the beginning, that their movements for ever correspond, is a system of which no argument can do more than prove the possibility. And, amid all the talent and acuteness with which these doctrines are supported, it seems to argue some unsoundness of understanding, to have thought that they could ever find a place among the established principles of human knowledge.

Newton did not aim at so wide a range. Fortunately for himself and for the world, his genius was more determined to a particular point, and its efforts were more concentrated. Their direction was to the accurate sciences, and they soon proved equally inventive in the pure and in the mixed mathematics. Newton knew how to transfer the truths of abstract science to the study of things actually existing, and, by returning in the opposite direction, to enrich the former by ideas derived from the latter. In experimental and inductive investigation he was as great as in the pure mathematics, and his discoveries as distinguished in the one as in the other. In this double claim to renown, Newton stands yet unrivalled; and though, in the pure mathematics, equals may perhaps be found, no one, I believe, will come forward as his rival both in that science and in the philosophy of nature. His caution in adopting general principles, his dislike to what was vague or obscure, his rejection of all theories from which precise conclusions cannot be deduced, and his readiness to relinquish those that depart in any degree from the truth, are, throughout, the characters of his philosophy, and distinguish it very essentially from the philosophy of Leibnitz. The characters now enumerated are most of them negative; but without the principles on which they are founded, invention can hardly be kept in the right course. The German philosopher was not furnished with them in the same degree as the English, and hence his great talents have run very frequently to waste.

It may be doubted also, whether Leibnitz's great metaphysical acuteness did not sometimes mislead him in the study of nature, by inclining him to those reasonings which proceed, or affect to proceed, continually from the cause to the effect. The attributes of the Deity were the axioms of his philosophy; and he did not reflect that this foundation, excellent in itself, lies much too deep for a structure that is to be raised by so feeble an architect as man; or, that an argument, which sets out with the most profound respect to the Supreme Being, usually terminates in the most unwarrantable presumption. His reasonings from first causes are always ingenious; but nothing can prevent the substitution of such causes for those that are physical and efficient, from being one of the worst and most fatal errors in philosophy.

As an interpreter of nature, therefore, Leibnitz stands in no comparison with Newton. His general views in physics were vague and unsatisfactory; he had no great value for inductive reasoning; it was not the way of arriving at truth which he was accustomed to take; and hence, to the greatest physical discovery of that age, and that which was established by the most ample induction, the existence of gravity as a *fact* in which all bodies agree, he was always incredulous, because no proof of it, *a priori*, could be given.

As to who benefited human knowledge the most, no question, therefore, can arise; and if genius is to be weighed in this balance, it is evident which scale must preponderate. Except in the pure mathematics, Leibnitz, with all his talents, made no material or permanent addition to the sciences. Newton, to equal inventions in mathematics added the greatest discoveries in the philosophy of nature; and, in passing through his hands, Mechanics, Optics, and Astronomy, were not merely improved, but renovated. No one ever left knowledge in a state so different from that in which he found it. Men were instructed not only in new truths, but in new methods of discovering truth; they were made acquainted with the great principle which connects together the most distant regions of space, as well as the most remote periods of duration; and which was to lead to future discoveries, far beyond what the wisest or most sanguine could anticipate.

END OF THE FOURTH DISSERTATION.

DISSERTATION FIFTH:

EXHIBITING A GENERAL VIEW
OF THE
PROGRESS OF MATHEMATICAL AND PHYSICAL SCIENCE,
CHIEFLY
DURING THE EIGHTEENTH CENTURY.

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DISSERTATION FIFTH.

INTRODUCTION.

The progress of Mathematical and Physical Science during the brilliant period which closed with Newton and Leibnitz, has been treated with fidelity and sustained interest by the hand of a master, whose calm judgment weighed impartially the different claims of discovery, whose powers of illustration could expand the fine results, and whose luminous eloquence was commensurate with the dignity of the subject. To resume the Discourse, and continue it through the course of the eighteenth century, is a task of increasing difficulty, which would require vigorous resolution, patient research, and skilful selection. The materials are ample, indeed, but they are likewise multifarious, and often lie scattered among the countless volumes of the Transactions of Learned Societies. The picture to be delineated is not less imposing, and has far greater extent and variety of outline, while it exhibits more elaboration in its details.

Scientific discovery had, during this latter period, continued to advance with accelerated progression; and the triumphs of penetrating ingenuity, if not so transcendant, were equally conspicuous, more diversified, and were spread over a much wider surface. Observation was directed with greater skill and attention, and the delicate art of experimenting better understood, and more generally practised. The investigation of some intricate phenomena called forth the resources of a refined calculus; and this new Geometry, the most powerful instrument ever wielded by human genius, was then cultivated, especially on the Continent of Europe, with enthusiastic ardour and astonishing success.

Newton, the glory of our island, had no competitor save Leibnitz in mathematical invention; but his sublime discoveries in the highest walks of science—in Optics and Astronomy—gave him a pre-eminence far above the most towering rival. Yet such is the slow progress of innovation, even among the learned, that, for the space of nearly half a century, his Theory of Light was generally slighted, and the system of Universal Attraction treated as a mere fanciful hypothesis. The *Principia*, which crowned the exertions of the creator of philosophical science, was admired and imperfectly understood by a few of his countrymen, but had to undergo the ordeal of a rigorous and sometimes unfriendly examination by foreigners. Averse from the bustle and contention of letters, he delighted to pursue his profound researches in perfect seclusion, and had appeared satisfied with registering the grand series of discoveries in that concentrated form which best accorded with the tone of his mighty intellect. When afterwards persuaded reluctantly to publish those brief compositions, he could not submit to the drudgery of retracing his steps, or of expanding his demonstrations, and bringing them nearer the reach of his contemporaries. Newton was nine years in possession of the Method of Fluxions before Leibnitz struck into a similar path; nor did he give it to the world till an equal time more had elapsed. The rapid mind of the German philosopher had framed his *Calculus* with less regard to elegance and strict logic, but clothed it in a simpler and more definite notation or algorithm, which, from its aptness to improvement, has in the sequel conferred a decided superiority. The diversified occupations of Leibnitz allowed him to work only at intervals on his great invention; but he found most able and zealous coadjutors in the two Bernoullis, who laboured in promoting the new calculus with uncommon ingenuity, indefatigable activity, and even a contentious emulation. The Higher Analysis had by such exertions already acquired greater extension on the Continent than the Method of Fluxions at its first publication in England; and our mathematicians were hence unprepared to follow many of the abstruse and abbreviated demonstrations inserted in the *Principia*. The Differential and Integral Calculus having thus made such rapid advances abroad, continued for a long time afterwards to maintain a preponderating ascendancy. The marks of the Fluxionary Method, consisting in mere dots, and therefore not susceptible of variation or improvement, sensibly though indirectly checked the tide of invention in England; and perhaps the splendour of Newton's fame had some influence for a season in overdazzling the lustre of native talent. As a parallel instance, it may be remarked that nothing pre-eminent in science was produced by the French, for half a century after the epoch of Descartes.

The immediate successors of Newton were still imperfectly prepared to rise to the sublimity of their great master, or to scan the vast superstructure which his genius had reared. Yet was more scientific invention displayed by them than had appeared at any former period in England; and nothing but the comparison with transcendant powers of intellect could tend to depress their just merits. By their zealous efforts the System of the Universe was consolidated, and its outworks enlarged. Cotes, who was snatched away at an early age, discovered the beautiful theorems of Trinomial Factors, and multiplied the resources of integration by skilful applications of Logarithms and Circular Arcs. Brook Taylor laid the foundation of the Method of Increments or Finite Differences, solved some of the most intricate problems in Dynamics; and in this arduous department he successfully entered the lists with the celebrated Bernoullis. De Moivre and Stirling particularly distinguished themselves, by extending and applying the Doctrine of Series, a most important branch of the Fluxionary Calculus. In the great astronomical discoveries, England still led the way. Bradley, who has been justly styled the modern Hipparchus, combined the habits of accurate observation with the talent of acute discernment and felicitous invention. His analysis of the Aberration of Light furnished the first incontrovertible proof of our Solar System; while his fine detection of the Nutation of the Earth's Axis confirmed the Theory of Universal Attraction. Simpson, but above all Maclaurin, the elegant expounder of the *Principia*, likewise materially contributed, by their various mathematical researches, to the advancement of the science of Physical Astronomy. Nor was England less indebted to the ingenuity and exquisite skill of her artists, who now constructed instruments of a delicacy far surpassing any former attempts, and during the last century furnished for the most part the Observatories on the Continent.

Though France had for a very long time produced nothing in science of much originality or importance, the munificence of her government continued to encourage philosophical pursuits; and now, by directing the mensuration of the Meridian at the most distant points,—within the Arctic Circle, and under the Equator,—it procured accurate data for determining the true figure of our Planet. It was the more precise measure of a degree of latitude ascertained by Picard, that had at last enabled Newton to subject to the test of calculation his grand idea of extending the power of gravitation from the earth's surface, after the simplest law of decrease, to the orbit of the moon. But the satisfaction was reserved for the successors of our immortal chief, to see his determination of the oblate form of the earth, arising from the mutual attraction of all its particles, modified by the influence of centrifugal force, fully confirmed by a close investigation of the results of the skilful and laborious observations brought home by the French astronomers. Nothing, indeed, contributed so much to exalt the character of the Newtonian Philosophy on the Continent as those scientific expeditions; while the credit of the system of Descartes, which bears no such scrutiny, rapidly declined. Mathematicians, invited to a rich field of discovery, were eager to examine the *Principia* through all its details; and the progress which the New Calculus had made, provided them with instruments for this dissection. The profound author had left indeed several parts unfinished; of some of the more difficult problems he had merely sketched the solution; and he had commonly supplied the defects of his analytical procedure by the exercise of wonderful sagacity and penetration.

Maupertuis was the first mathematician of any note that ventured publicly in France to espouse the Newtonian Philosophy. But perhaps no writer contributed more effectually to promote its diffusion and popular reception than Voltaire, whose universal talent ranged through the sphere of human knowledge, and whose easy and simple style gave transparency to his conceptions. The French, at length awakened from the Cartesian dreams, and directed into the path of inductive philosophy, again put forth their inventive powers. The fine genius of Clairaut and D'Alembert early soared to the highest distinction in scientific research. Both these illustrious men showed, from their infancy, the strongest disposition for mathematical studies, which they cultivated with the most ardent and persevering application, and displayed in their profound investigations all the rich and varied stores of original invention.

Clairaut began his labours with a capital extension of the Theory of Curve Lines. But, in his riper years, he directed the whole force of his ingenuity and analytical skill to explore the depths of Physical Astronomy. He deduced the figure of the earth strictly from the principle of universal attraction, with the admission only of the very simplest conditions. But not content with mere speculation, he sought the practical solution of that problem, and therefore eagerly joined the Academicians who were dispatched to measure a degree of latitude within the Arctic Circle. After achieving this grand operation, he resumed with vigour the examination of the Newtonian System, and concentrated his utmost exertions in resolving the arduous problem of *the three bodies*, or in determining the influence of a planet or the sun to modify the motion and orbit of another planet or satellite. The Integral Calculus furnishes yet no direct or absolute solution. It became necessary to proceed by a train of successive approximations, simplifying and condensing the computation by the judicious rejection of the small excrescences.[1] But the first result was most perplexing, and seemed to betray an evident imperfection in the great Law of Gravitation. Not discouraged, however, by this repulse, the persevering analyst pushed his calculations still farther, and collecting the minor terms of the series, at last arrived at a conclusion entirely conformable with observation, and thus established beyond all dispute the harmony of the Theory of Attraction.

But Clairaut did not rest satisfied with speculative conclusions, however beautiful; he sought to embody his *formulæ* in real numbers; and availing himself of the aid of some expert calculators, he soon produced a set of Lunar Tables, much more accurate than had been yet attained. Encouraged by such eminent success, he now directed his inquiries to the more distant objects of our system. The comet, whose return was predicted by the sagacity of Halley, did not appear at the time assigned, and astronomers began to feel uneasy at their disappointment. From this state of inquietude they were soon relieved by the soaring investigation of Clairaut, who found that the disturbing influence of Jupiter and Saturn would retard for several months the advance of the distant stranger, and computed with surprising nearness, from his imperfect data, the time of the comet's actual appearance. But excessive application and the solicitations of society preyed on a languid frame, and premature death tore away that brilliant genius in the midst of his career of triumph and applause.

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[1] The question especially selected was the annual change of the position of the axis of the moon's elliptical path about the earth, occasioned by solar attraction.

D'Alembert, who rose to still higher celebrity, and contributed to distinguish the character of the age in which he lived, closely followed in this research, though by a different path; encountered similar difficulties, obtained the same partial result, but finally arrived at a like satisfactory conclusion. He carried his acuteness and penetration into all the abstruse departments of physics, and marked his progress by originality of conception. The success of this most ingenious philosopher would have been more complete, if he had confined his views to the pursuits of abstract science. But he wanted that patience to which Newton, with innate modesty, ascribed all his advantages. In discussing the most arduous questions, D'Alembert advanced generally by new paths, and displayed great resources and much versatility of talent. He would seldom retouch his formulæ, or seek to mould them into simplicity and elegance, and never submitted to the labour of reducing them to actual application. Ambitious to excel in literature as in science, he transferred into his miscellaneous compositions the same strict logic and nice discrimination which guided his analytical researches, and likewise contracted a corresponding style, remarkable for the qualities of precision and clearness, but possessing no warmth or elevation.

The last of the three illustrious men who, by separate roads, arrived at the same conclusions, and thus concurred in fixing the true system of the world, was Leonard Euler, born near Bâle in Switzerland, and educated under the Bernoullis, but who, patronised by foreign courts, passed a very long and most laborious life at St Petersburg and Berlin. He was indisputably the greatest analyst that has ever appeared, displaying infinite address, perspicuity, and elegance in his mode of investigation, and pursuing or transforming the most intricate calculations with such astonishing readiness and rapidity, as if they seemed only mere pastimes to recreate his invention. But the supremacy of Euler was confined to his unrivalled skill in applying analysis; he attained little eminence in philosophy and general science, and showed no relish for the charms of literature. His improvements and discoveries, however, during a life of assiduous and unremitting labour in every branch of the Calculus, form a monument of the most stupendous magnitude.

Our island, after the decease of Maclaurin, produced none to compete with the great mathematicians of the Continent, except Thomas Simpson, whose native talent had struggled through indigence and a neglected education. He solved with commendable neatness and brevity several of the difficult questions of Physical Astronomy; but he was deficient in taste and method, and only followed tardily and at a distance those masters in science. For a long period afterwards the inventive genius of England appeared to slumber. The learned were content with merely commenting on the *Principia*, but rarely borrowing a few scattered lights from abroad. The current of investigation was diverted into other channels, or absorbed among humbler objects. In the meanwhile, a new and brilliant science, beyond the dominion of Mechanical Philosophy, had been gradually forming, to which our experimenters contributed their full share. Electricity captivated its numerous cultivators by surprising and splendid displays; but though it engaged the imagination, it afforded little exercise to the judgment, and was not fitted to call forth the higher mental energies. The application of English talent was now mainly directed to the improvement and extension of the mechanical arts, though perhaps few nations in Europe have less availed themselves of the results of abstract science towards aiding and correcting the operations of practice.

In the career of the sublimer sciences, the Continent for a long time afterwards maintained its ascendancy, which was secured by the very superior skill displayed in managing the integral calculus, with its improved and refined notation. But a succession of minor discoveries continued to expand and consolidate every department of Natural Philosophy. Daniel Bernoulli, the most amiable, if not the most ingenious of that shining family, embraced with candour the doctrine of Newton, and likewise evinced, in all his physical researches, a considerable share of the sagacity and singular address which so eminently distinguished that great master. The attention of Lambert was diverted to a wide variety of pursuits, and his original and excursive mind shed new lights on every subject it explored. He conjoined analytical skill with the talent of experimental research. But unfortunately he contented himself in operating with rude instruments, and commonly trusted to the probability of rectifying such imperfect results by the help of combined calculations. If Mayer had not the same reach and versatility of genius, he possessed that inciting ardour and unconquerable perseverance which enabled his discrimination to erect a durable monument. Adopting the clear formulæ of Euler for the several elements of the moon's motions, he deduced the indeterminate co-efficients from a strict and most laborious comparison of Bradley's observations, and by thus poising and adjusting the numerical quantities, he framed a body of Lunar Tables, which has long been regarded as a standard of excellence. It is thus that England has generally supplied the means which rendered the conclusions of the Continental mathematicians really available. The reflecting instrument of Hadley, the achromatic glass of Dolland, and the dividing machine of Ramsden, have, in succession, mightily contributed to the progress of practical astronomy. The numerous observations of Bradley and Maskelyne furnished the correct data which guided Lagrange, Laplace, and Gauss, through all their profound researches, to the discovery of the cyclical and reciprocating motions of the heavenly bodies. The various disturbing causes incessantly in operation are, after the lapse of certain vast periods, again renewed and repeated in the same order of succession, and thus preserve the fine harmony, and maintain the permanent stability, of the Universal System.

The British mathematicians had long neglected the cultivation of the Higher Analysis, and were perhaps the more disposed to overlook its pre-eminent advantages, from observing the course of their brethren on the Continent, who, on various occasions, after magnificent displays of the powers of calculation, but either from their incomplete integrations or the defective statement of the physical principles, arrived merely at the same imperfect conclusions that had been discovered before by much simpler means. Our island has at last resumed its proper station in the loftiest departments of science. Emancipated from the trammels of a narrow notation, the more aspiring votaries pursue with ardour the most refined calculus; while they guide its application and avoid its abuse by the infusion of that spirit of purity and elegance derived from the discipline of the ancient geometry. Among the illustrious few whom foreign nations would adopt with distinction, we may cite the gifted individual who, rivalling the fame of Lagrange and Laplace, has, in his beautiful solution of the problem of the Attraction of Spheroids, struck out a new and direct path, which completely throws into the shade their very laborious and perplexed trains of investigation.

Having traced the great outline, it only remains to sketch the plan of this Dissertation. I shall arrange Mathematical and Physical Science under the two great heads—of *Pure* or *Speculative* Science—and that of *Applicate* or *Practical* Science; each of these again to be classed in subordinate divisions. Pure Mathematical Science includes Geometry, Arithmetic, Algebra, and the Higher Calculus. Its applications are very numerous and diversified; but without pursuing the details, our attention will be mainly directed to the progress of general and pervading principles.

Physical Science occupies a confined space till it receives the accession of Mathematics, with which it becomes always the more blended in proportion as it improves and expands. Pure Physics at present appears limited to Magnetism and Electricity, which have yet drawn scarcely any aid from the disquisitions of Geometry. The infusion of Mathematics into Physics, and the application of Physical Science to the Practical Arts, led to the most wonderful results, which have aroused the ingenuity and vastly multiplied the productive industry of the eighteenth century. Applicate Physical Science embraces Dynamics, Hydrostatics, Pneumatics, Optics, Electricity, Magnetism, the Doctrine of Heat, Meteorology, Geography, and Astronomy. In discussing these important subjects, separately or inclusively, incidental lights will be reflected on General Mechanics and the Elements of Naval Architecture.

SECTION I.

SPECULATIVE MATHEMATICS.

1. GEOMETRY.

Pure Geometry is in strictness limited to the mere equality of lines, angles, and spaces, whether superficial or solid. It owes its main extension to the principle of comparison or the doctrine of proportion, which is really but an application of Arithmetic, the idea of Number being transferred to Quantity or Magnitude by a process of subdivision. Such concert has produced the most perfect of abstract sciences, and erected the noblest monument of the genius and invention of the ancient Greeks. That acute people nearly completed the Elements of Geometry; and carrying their speculations beyond the properties of the Circle, they investigated the Sections of the Cone, and traced the character of some of the Higher Curves. The demonstrations left by the Greek Geometers are models of accuracy, clearness, and elegance—admirably calculated for training the minds of youth to habits of close reasoning and luminous arrangement. The circumspection of those great instructors of mankind in distinguishing the several cases, and marking the limitations of a proposition, though frequently bordering on prolixity, might serve to warn the rapid cultivator of Algebra against indulging the tendency to hasty generalization which has given rise to the various paradoxes, and even palpable absurdities, that still disfigure the excellence of the modern art. The method of Geometrical Analysis, which investigates the construction of a problem, by remounting from its conditions along a chain of dependence to some known property, affords decidedly the best exercise and initiatory discipline for the student in Mathematics. It imbues the mind with a taste and elegance which insensibly extend their influence over the culture of the other sciences. The most curious and difficult portion, however, of the Greek Geometry, has unfortunately been transmitted to us in a mutilated and imperfect state, which has often tortured the skill of commentators and mathematicians to restore it. Soon after the revival of letters, the principal works of the Greek Geometers were translated in Italy by Commandine; but of Apollonius' Conics several books are wanting, and some parts of the Collections of Pappus exhibit only detached fragments. Near the close of the sixteenth century, and early in the seventeenth, Vieta, from a few scattered hints, restored the lost Tract on Tangencies, Fermat framed some beautiful separate demonstrations, and Snellius reproduced the Plane Loci, but in a tasteless shape. Soon afterwards Viviani, the surviving disciple of Galileo, supplied the fifth book of Apollonius, and with such remarkable success, that on comparing his production with an Arabic version just then discovered, he appeared to have surpassed his original. Huygens[1] afterwards gave, in the purest taste, some specimens of the Ancient Geometry. A Collection of the Mathematical Treatises of the Greeks respecting the Art of War was now published in a magnificent folio from the Royal Press at Paris. But a more extensive undertaking was planned by our oriental traveller Bernard, to print at Oxford a complete series of the Greek Geometers, filling up the blanks from the inspection of Arabic Manuscripts. In pursuance of this scheme, Dr David Gregory[2] edited Euclid, and Dr Halley[3] Apollonius, while he restored likewise the Tracts on the Section of Ratio and of Space. After an interval of fourscore years, Torelli's[4] elegant edition of Archimedes, purchased in Italy, has issued from the same press. Every lover of science would rejoice to see a portion of those ample funds that have been provided at Oxford for the encouragement of such expensive works, appropriated to the republication of Pappus' Mathematical Collections, of which several manuscripts exist far more complete than the copy printed by Commandine.

The relish for the Ancient Geometry has been longer preserved in Italy and in England than over the rest of Europe. But no person ever cultivated that fine science with more assiduity, perseverance, and success, than our countryman Dr Robert Simson[1] of Glasgow, the learned and critical editor of Euclid's Elements. In this department he concentrated his whole efforts, and appears, from his familiarity with the ancient mode of demonstration, to have inhaled the very spirit of the Greeks. In 1749, he published his Restoration of the books of Apollonius on Plane Loci, which by its fulness and peculiar elegance leaves scarcely a shadow of regret for the loss of the original. Simson pursued his researches in the Ancient Analysis through a long life, and not only restored various fragments, but threw light on some very difficult and abstruse questions connected with it. A posthumous volume, printed in 1776, at the expence of Earl Stanhope, besides many fine geometrical speculations, contains the first satisfactory exposition of Porisms, of which the definition advanced by Pappus had been commonly regarded as an incomprehensible enigma. But from the unvarying tenor of his studies, the Scotch professor became a *rigorist* for the Ancient Analysis, and rejected with disdain the most obvious improvements in the form of exhibition. It deserves remark, that mathematical demonstration, being addressed to the eye rather than to the ear, must attain its greatest perspicuity when the successive steps of reasoning are seized at a glance. This is effected by adopting the symbols of Algebraic Notation, the most concise and perfect of all written characters; nor is the beauty and logical accuracy of the procedure in any degree impaired by such a transparent covering.

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[1] Born at the Hague in 1629, and son of the Lord of Zuylichen, Secretary to the Prince of Orange; completed his mathematical studies at Leyden under Schooten, and printed a beautiful tract on the Circle and Hyperbola in 1651. But after visiting different countries, he published in 1658 his original and immortal work entitled *Horologium Oscillatorium.* Having successfully applied the pendulum and the spiral spring to regulate the motions of clocks and watches, he was anxious to accommodate those instruments to the finding of the longitude at sea. For that purpose he visited England, where he was treated with distinction; but returning in 1663 through France, he was induced by the Minister Colbert to accept of a large pension, and fix his abode at Paris. There he resided till his health became impaired, and in 1681 he retired to the calmer enjoyment of his native country. The same pursuits, however, engaged his attention, till his death at the Hague on the 8th of June 1695. He was one of the clearest writers and most elegant geometers of modern times, and his powers of invention have seldom been surpassed. The finished works of Huygens have been collected at two several times into three quarto volumes.

[2] Nephew to the famous James Gregory, born at Aberdeen in 1661, completed his education at Edinburgh, and was appointed Professor of Mathematics in that University in 1683, the office having been suffered to remain vacant for eight years after the death of his uncle. In 1691 he had sufficient interest to obtain the Savilian professorship at Oxford, and had the honorary degree of Doctor in Physick conferred on him by the University. He published his Elements of Astronomy in 1702, and in the following year brought out his Edition of Euclid. He had made some progress in preparing the Conics of Apollonius, but fell a sacrifice in 1710 to an attack of malignant small-pox, at Maidenhead, where he chanced to stop at the Inn, on his return from a visit to Bath. He possessed some learning, but his genius was of a very inferior order to that of his uncle.

[3] Edmund Halley, born in London October 29. 1656, the son of a substantial citizen—educated at St Paul's school, and sent to Oxford in 1673—sailed for the island of St Helena in November 1676, and returned with his catalogue of fixed stars after an absence of exactly two years—elected immediately fellow of the Royal Society, and deputed by that learned body in 1679 to visit Hevelius, at Dantzic, and examine his observatory—spent the years 1680 and 1681 in France and Italy. In 1684, having turned his attention to Kepler's problem, he tried, as some other mathematicians about this time had done, to derive it from a graduating central force, but was unable to find a geometrical demonstration; and not obtaining any help as he expected in this investigation from Hooke or Wren, he had recourse to Newton, who astonished him at Cambridge by the store of his grand discoveries, condensed into eight general propositions. He overcame the scruples of the modest philosopher, and prevailed with him to arrange the materials of the *Principia*, of which he superintended the publication in 1687, having written the preface and some elegant recommendatory verses. Halley now gave a geometrical construction of the higher equations, computed the effects of evaporation in the Mediterranean, and formed tables of life annuities. For the purpose of improving Nautical Science, he had the command of the Paramour Pink, with which he sailed from England on the 24th November 1698, traversed the Atlantic, and crossed the Equinoxial Line; but his crew growing sick and mutinous, he was obliged to return in the following June. Invested with fuller powers, he set sail again in September, and spent twelve months in exploring both hemispheres, and during the year after his return, he delineated and published his famous magnetical chart. He was next employed on a survey of the British Channel, and then sent by the English Government to assist her ally the Emperor of Germany in forming a harbour at the bottom of the Adriatic. On his return he was appointed, in November 1703, Savilian Professor of Geometry at Oxford, having been thwarted before in a similar canvass by clerical influence. He now set about recovering the works of Apollonius; studied as much Arabic as enabled him to translate the tract on the *Section of Ratio*, and he restored the other tract on the *Section of Space* from the hints left by Pappus. These pieces, in a small octavo volume, appeared in 1706; but four years afterwards came forth, in a splendid folio, his edition of the Conics, with the eighth book restored, and the additional treatise of Serenus. In 1719 Halley was appointed astronomer royal, and resided at Greenwich during the rest of his life, devoting his advanced age to the careful and assiduous observation of the Heavens. He completed even his projected task of embracing a lunar period of eighteen years. A paralytic disorder seized him in 1737, from which he partially recovered, but his strength declined insensibly, and he expired on the 14th of January 1742. Few philosophers have contributed more largely to the advancement of useful knowledge. Ingenuity, ardour, indefatigable perseverance, learning, and general information, were possessed by Dr Halley in a most eminent degree; and having mingled in the active scenes of life, he had the rare advantage of conjoining the love of study with the habits of social intercourse.

[4] Born in 1721 at Verona, where he died in 1781. He studied at Padua, and became a great linguist, a good mathematician, and an excellent critical scholar. Being in easy circumstances, he devoted his whole time to literary pursuits, and carried his admiration of the Ancient Geometry almost to a pitch of bigotry.

Dr Matthew Stewart[2] of Edinburgh, who had been the pupil of Dr Simson, and possessed a much richer invention, was likewise an able and zealous promoter of the Greek Geometry, which he directed besides to the investigation of certain difficult parts of Physical Astronomy. But though managed with sufficient address, the instrument he employed was hardly fitted for exploring the more abstruse and recondite problems, which often require all the concentrated powers of the Modern Analysis. The conclusions at which he arrived display much elegance, though merely approximative, and devoid of the precision that is indispensable in the present advanced state of Astronomical Science.

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[1] Born at Kirtonhall in Ayrshire on 14th October 1687, studied at Glasgow, and made such progress in elementary geometry, that at the early age of 22 he had an offer of the professorship of mathematics, which was immediately expected to become vacant in that University. Feeling his deficiency, however, he obtained leave of a year's absence, which he spent in London under the tuition of Humphry Ditton, and was admitted to the chair on the 20th of November 1711. His time seems afterwards to have been mostly spent in discharging the duties of his office, the intervals being allotted to the solution of geometrical problems, the perusal of the older mathematicians, and to miscellaneous reading. He led the life of a recluse, and all his steps were formal and methodical; yet his disposition was amiable, and he indulged at stated times in easy conviviality. He sent two papers, geometrical and algebraical, on Indeterminate Problems, to the Royal Society in 1723 and 1753, gave his restoration of the Loci Plani in 1745, published his Conic Sections in 1735, produced the Latin edition of Euclid's Elements in a quarto volume in 1756, which he compressed in 1760 into an English octavo, to which he annexed the data in 1762. It contains only the first six books of the original, with the eleventh and twelfth, the rest of the books being omitted as of little consequence in the present state of science. Perhaps the selection should have been carried farther. This edition is correct and creditable to the compiler, and has obtained prodigious success. Nay, the very Scotticisms with which it abounds appear now to be adopted at Oxford and Cambridge as the appropriate diction of the Ancient Geometry. Simson quite idolized his original. He had a fine taste for geometry, some talents of invention, and considerable attainments as a scholar, but without any great force of intellect. In his latter years, from excessive veneration of the Greek Geometry, he not only viewed the Cartesian method with aversion, but began to regard the Fluxionary Calculus with mistrust and suspicion. He became *emeritus* professor in 1761, and died on the 1st of October 1768.

[2] Born in 1717 at Rothsay, in the Isle of Bute, of which place his father was minister; studied seven years at Glasgow, where he distinguished himself; to gain farther instruction, in 1741 he removed to Edinburgh, where he cultivated the society of the celebrated Maclaurin, while he corresponded with Simson, his old master. He now prosecuted geometrical studies with ardour, and put forth his uncommon powers of invention; and after he became minister at Roseneath, he found leisure in that seclusion to continue his favourite pursuits. On the occasion of a vacancy of the mathematical chair at Edinburgh by the death of Maclaurin, he was induced to draw out the substance of his most profound geometrical investigations, which he printed under the title of General Theorems, in a small volume, about the close of 1746. This publication secured his election, and after some delay he was appointed professor in September 1747. He now enjoyed a situation most congenial to his taste, and favourable to the exercise of his rare talents. Ambitious to apply his beloved geometry to unravel questions which were believed to demand all the resources of algebraic art, he discovered a solution of Kepler's problem at once simple and direct, and greatly surpassing in beauty the more laboured efforts of calculation. This investigation was inserted in the second volume of the Transactions of the Edinburgh Society, which appeared in 1756. Encouraged by such success, he five years afterwards produced his Physical and Mathematical Tracts; a very ingenious and elegant work, which would have been clearer had the author only admitted an abbreviation by the simpler algebraic symbols. About this time the results of the observations of the Transit of Venus, which had been expected to give the true distance of the Sun, were found to be unsatisfactory and discordant. Stewart therefore published in 1763, as a sequel to his Tracts, a theoretical solution of the problem; in which he was directed by Geometry to the exact motion of the Lunar Apogee, a question that, since the analysis of Newton, had perplexed the greatest mathematicians. But he was not equally felicitous in Determining the Solar Distance, which required the inversion of the problem, and involved some deceitful and precarious compensations of error. This pamphlet was his last production, having printed only a few months before an octavo volume under the title of *Propositiones More Veterum Demonstratæ*. These propositions, however, derive their value merely as exercises of the method of conducting geometrical analysis and synthesis. But his lamp of genius was already nearly extinguished. Dr Stewart fell into a state of bad health, and having devolved the charge of teaching on his son, then a youth of the highest promise, he retired in 1772 to a small paternal property in Ayrshire, where he chiefly spent the rest of his days, and died on the 23d of January 1785.

I need not stop to notice the attempts of other English mathematicians, to restore some fragments of Apollonius. After the principal demonstration was obtained, there could be little difficulty in evolving its different phases, and modifying it to the several cases. Playfair's elucidation of the nature of Porisms is entitled to higher distinction.

It has often been matter of surprise, that the Greeks should have spent so much ingenuity, and set such a high value on the Geometrical Construction of Problems. But the application of Geometry served them in some measure the purpose of calculation, and became a sort of substitute for the tedious and laborious operations of their imperfect system of Arithmetic. Accustomed, as we are, to the extreme facility of computing by help of the Arabic ciphers, we can form no adequate conception of the toil of working with alphabetic numerals, though the Greeks had made some capital improvements in their system of notation. They could extract laboriously the Square Root of a number, but never attained the extraction of the Cube Root, which it appears was first discovered many centuries afterwards by the Arabians. Hence undoubtedly the solicitude of the Greeks to solve, by a Geometrical, or even a Mechanical Construction, the famous Delian Problem, or the Duplication of the Cube.

It would seem that, in finding the square root, the Greek mathematicians must have employed certain methods of abbreviation which are not explained. Archimedes, in his famous Quadrature of the Circle, to which he approximated by measuring the successive inscribed and circumscribing polygons, having occasion repeatedly to extract the square root, expressed the value by fractions, and yet with such felicity as always to adopt the lowest integral numerator and denominator. He thus discovered that the circumference of a circle is less than $3\frac{1}{7}$ times and greater than $3\frac{10}{71}$ times its diameter, or that their ratio lies between the ratios 7 to 22 and of 71 to 223.[1] This approximation within the limits of the 2000th and 4000th parts, might be sufficient for ordinary practice. But Apollonius and Ptolemy afterwards approached a hundred times nearer. Yet no farther advances were made in solving that important problem, which required the most refined address, till the lapse of near a thousand years, when the Arabians became possessed of the denary system of notation, and carried the expression for the circumference of a circle to ten decimal places. But this elaborate result was imperfectly known to the revivers of science in Europe; and Victa, Adrianus Romanus, and others, exerted their ingenuity and patience in extending the earlier solution. The simplest and most elegant is that of 113 to 355, an approximation differing scarcely by the ten millionth part from the truth, which was discovered about the year 1585 by the elder Adrian Metius, a military engineer in Holland. His countrymen Van Keulen and Snellius, in the next century, pushed the expression for the circumference of the circle to 35 figures. But the progress of the higher analysis opened more easy and rapid modes of approximation. In the early part of the eighteenth century, Sharp[2] and Machin[1] computed in England the quadrature of the circle to 75 and 100 places of decimals, and Lagny in France advanced to 128 figures. But these labours were outdone by Vega,[2] an officer of artillery in the Austrian service, who amused his leisure during a campaign, in employing one of Euler's formulæ to derive the length of a quadrant from the tangents of fractional arcs, carried the expression to 140 decimal places. This was the *luxury* of calculation; and though no doubt superfluous, it might at least convince any judicious person of the impossibility of stating the ratio of the diameter to the circumference in finite terms. Yet the squaring of the circle is a problem which has at all times fascinated the attention and bewildered the reason of many superficial or antiquated students in Geometry. The incommensurability of the circle, which James Gregory had attempted to prove in 1661, was finally demonstrated a century afterwards by Lambert, from an ingenious transformation of the known series for the quadrantal arc in terms of its tangent or the radius. The same ingenious mathematician likewise proposed several neat geometrical constructions, for approximating to the length of arcs of a circle still more nearly than the methods given by Fermat, Gregory, Huygens, and others.

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[1] This ratio, it may be observed, is easily derived from the limits assigned by Archimedes, for $71 + 7 \times 6 = 113$, and $223 + 22 \times 6 = 355$.

[2] Abraham Sharp, born at Little Horton, in the West Riding of Yorkshire, in 1651, was apprenticed to a merchant at Manchester; but preferring the study of mathematics, he supported himself by teaching a school in Liverpool. Here he engaged as amanuensis to Flamsteed, and became his assistant when the Royal Observatory was erected at Greenwich in 1676. His services were most eminent in every department. He constructed optical and astronomical instruments, observed stars, calculated tables, and delineated celestial charts. His peculiar neatness of execution is displayed in a small geometrical work which he published in 1717. About that time he seems to have retired to his native village, where he led the life of a hermit, but esteemed for his quiet and beneficent disposition. He died in 1742.

Elementary Plane Geometry rests on the combined properties of the *straight line* and the *circle*. Many important additions have been made to the digest of Euclid; and several eminent mathematicians of the eighteenth century have corrected, simplified, and essentially improved the only valuable portion of the large work.[3] Some remarkable propositions, derived from sources beyond the usual scope of Geometry, are yet assimilated with that science. Of such accessions, one of the most beautiful is the late curious and unexpected discovery of Gauss, that, besides the ordinary regular polygons, a numerous class more complex, including the next polygon of seventeen sides, are capable of being inscribed within a circle, by a mere geometrical construction.[1]

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[1] John Machin, elected professor of Astronomy in Gresham College in 1713, and became secretary of the Royal Society. He had the reputation of being an able mathematician, yet his essay on the Laws of the Moon's Motion, in which he attempted to rectify the *Principia*, was but a superficial performance. He died in 1751.

[2] This excellent mathematician, who published in 1794 a complete collection of Logarithmic Tables and Analytical *Formulæ*, was eight years afterwards robbed and barbarously murdered by a miller, in whose house he lodged, and his body thrown into the Danube.

[3] It may be sufficient perhaps to notice the Elements of Geometry by Thomas Simpson, and the similar treatises in the French language by Clairaut and Legendre. These productions all unite clearness with precision; and excluding whatever appears superfluous, they still comprise the whole series of connected propositions. Simpson's unpretending volume is neat and very brief, yet sufficiently perspicuous. The Geometry of Clairaut is still shorter, but has an air of originality, being designed to show the road of induction, or to guide the learner through his efforts at the solution of geometric problems, to discover the great elementary truths. He followed the same plan, and with more complete success, in his excellent Elements of Algebra. But the Geometry by Legendre claims much higher merit, and is perhaps the best on the whole that has yet appeared. It were vain, however, to expect perfection: the steps of his demonstrations are sometimes incomplete, and his entire separation of the problems is at least a very questionable improvement. The notes he has added are valuable, but appear disproportioned to the text, and certainly too profound for beginners. This elegant geometer attempted to found the comparison of triangles on abstract considerations derived from the common theory of functions. But such reasonings *a priori* are fallacious, involving unperceived some metaphysical assumptions.

The works now mentioned might suffice for the instruction of practical or professional men; but the pursuit of a liberal education aspires to greater attainments. The main object is to sharpen the faculty of perception, and invigorate by due exercise the tone of the intellectual powers. For contributing to that effect, the fulness and circumspection of the ancient mode of demonstration are admirably calculated. It seemed, therefore, an estimable task to select the scattered wrecks of the Greek Analysis, and dispose them into a form accessible to ordinary students. The beauty of the propositions concerning *Loci* was particularly striking.

It would be preposterous, however, to hold up the Elements of Euclid as a standard of instruction in Geometry for the present day. They were composed before the invention of Trigonometry, and probably designed chiefly as an introduction to the Pythagorean Philosophy. Hence the large portion of them devoted to the relations of numbers, and the properties of the regular polygons and solids. By common consent, therefore, the greater part of the system is now laid aside, and the other books are commonly altered or curtailed in practice. Many trivial propositions occur in the third book; several of the fourth have little interest; and it may abate that extravagant praise which several mathematicians have lavished on the Doctrine of Proportion contained in the fifth book, to know that it really cannot be taught. But the language employed in that celebrated compilation, for want of appropriate technical terms, is often vague and indistinct. The word *angle*, for instance, has no less than three different significations; and other examples of a like confusion might be easily cited. In some cases, the demonstrations of Euclid are imperfect or inconclusive. Thus, the reasoning in the twenty-fourth proposition of the first book applies only to the particular position of the figure; an objection first started by Thomas Simpson, to the great annoyance of his critical namesake. But similar oversight was made in the demonstration of the seventh proposition of the same book, which fails if the figure be changed. Both these propositions are only of consequence as auxiliaries in the train of combination. But of the fundamental property of parallel lines, the demonstration rests on the mere assumption of an intricate axiom. In a few cases the reasoning is unnecessarily complicated, from the peculiar conceptions of the author. Thus, the noted fifth proposition of the first book is of that description. Its demonstration implies the reversed application, at least mentally, of the isosceles triangle; but Euclid evades or disguises the process, by producing the sides of the triangle, and forming two interwoven triangles, which are virtually adapted by inversion, and the annexed triangles being then taken away, the equality of the angles at the base hence follows. But the last is the only step wanted, and the other two were evidently superfluous. This stumbling proposition has been called the *Pons Asinorum;* and no wonder that the beginner should feel puzzled at seeing such a parade of argument end in so plain a result.

In solving the common problems, the straight line and the circle are generally combined, which requires the application of both the *ruler* and the *compasses.* Schooten effected by the ruler alone several simple constructions, of use particularly in castrametation. But the late Mascheroni[2] of Bergamo, in a small work which appeared in 1795, made a beautiful addition to Elementary Geometry, by the solution of a variety of problems, especially those concerning the inscription of the regular polygons, with the help exclusively of compasses. Such speculations, however, are in a great measure extraneous to the science.

The theory of Lines of the Second Order forms one of the finest speculations of the more advanced geometry. These curves were derived from the Section of the Cone; but the clearest and most philosophical way of treating them is by considering their description on a plane. The distinguishing property of the foci was known to Apollonius, but the advantage of its application overlooked. The Parabola forms the intermediate transition of the Ellipse to the Hyperbola, the remote focus stretching farther out, till it vanishes into indefinite space, again to re-appear on the opposite side. The features of the Parabola are therefore not strictly included in the phases of the Ellipse and Hyperbola. The more comprehensive relation of the distances of any point in the curve from a focus and the directrix is mentioned by Pappus, but the beauty of that locus was not perceived till Boscovich, in 1752, deduced the properties of those lines from it in a string of corollaries, more ingenious than elegant. This essay was compressed and methodized by Thomas Newton in 1794; and in the same year Walker, a respectable mathematician, unaware of what had been already done, produced a work on a similar plan, of which the first part occupied a quarto volume, composed indeed after the manner of the ancients, but so exceedingly prolix in diction as to have very few readers.

An elegant mode of investigating curves of the second or higher orders, is to consider them as generated by the conditional intersection of angles or lines turning about fixed points or *poles.* The property had been stated generally in the *Principia*, but was expanded in 1720 by Maclaurin in his *Geometria Organica.* The intersections of *Polar Radiants* were discussed by Brackenridge in 1733. The subject has been again revived, and prosecuted with great ingenuity and research, by the celebrated Carnot, under the denomination of *Transversals.*

No part of Geometry has been more improved in the course of the last century than Trigonometry, which is not only simplified but much extended in its application. The theory of planes and solids has likewise been cultivated with eminent success. As the position of a point on a plane is assigned by referring it to two co-ordinate lines, so the place of a point in space may be determined by its distances from three planes which are mutually perpendicular. The properties of a line of single curvature may be derived from the equation of its co-ordinates; the properties of a curved surface can likewise be deduced from its triple shades, or the perpendicular projections on the three planes. Such is the process employed by Monge[3] in his *Descriptive*

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[1] Gauss found that the expression for the multiple cosine is always decomposable into binomial factors, and hence concluded that any regular polygon, the number of whose sides is a prime, and denoted by $2^n + 1$, may be inscribed in a circle by mere Elementary Geometry. These numbers form the series 3, 5, 17, 257, 65537, &c. of which the first two only were known before.

[2] Born in 1750; died at Paris, July 14, 1800. His tract on the *Compasses* happening to fall into the hands of General Bonaparte during his first triumphant campaign in Italy, this extraordinary man was so struck with its ingenuity, that, on his return to Paris, he communicated, in conversation, some of the propositions to the members of the Institute. The book was immediately translated into French, and the author promoted to a place of trust and emolument in the Italian Republic.

[3] Gaspard Monge, born in 1746 at Beaune, and educated at the Jesuits' seminary at Lyons. His uncommon talent for drawing procured him admission into the Military School at Mezieres, where he soon became assistant teacher. Disgusted

Geometry, which may be considered as the completion of the analytical method of Descartes. It furnishes direct and general solutions of several important problems, especially of those relating to the intersection of planes and the constitution of solids. Descriptive Geometry comprehends also the theory of Perspective, which was founded by Ubaldi, and long afterwards recast and simplified by Brook Taylor, and rendered still more practical by Lambert.

2. ARITHMETIC.

To express large numbers by continued additions being impossible, it soon became necessary to arrange them on a scale of ascending progression. The simplest mode was evidently to repeat the same root of the scale; and as men in the earlier periods of society used to reckon with the ten fingers of both hands, they were led by Nature herself to frame the *Denary System* of Numeration. If they had likewise formed marks for a Digital Notation, they would have completed the bases of Arithmetic. But unfortunately the Alphabetic Characters had been introduced before distinct symbols were contrived to represent numbers. The letters designed merely for written language, came hence among all nations to be employed besides in numeral notation, though hardly manageable, and ill adapted to any regular system of arrangement. In the application of those characters the ancient Greeks showed great ingenuity, by distinguishing them into three classes, appropriated to the ascending progression of units, tens, and hundreds. In this way they reached the term of a thousand, and by employing as an auxiliary the capital M, they could indicate myriads or ten thousands. The triple series of thousands up to a million were more easily denoted, however, by placing a dash under the successive sections of letters. But Archimedes indicated a mode of obtaining almost unbounded extension of this system, by decomposing the elements of the notation into periods of ascending myriads. Apollonius simplified the plan, by adopting a *thousand* as the root of the progressive scale. Had he proceeded only a little farther, and rejected the letters, except the first class denoting digits, he would have rendered his notation perfect, and have achieved one of the most useful and prolific discoveries ever made. Ptolemy afterwards advanced much nearer to this ultimate object, by employing, in his Trigonometrical Tables, the descending *Sexagesimal Scale*, suggested by the subdivision of the circumference of a circle into degrees, of which *sixty*, or the root of this scale, correspond nearly to the length of the radius. It would seem, however, that, during the interval between Archimedes and Ptolemy, the Greek Arithmetic had received some essential improvements in practice; for the Sicilian geometer, by a very tedious and operose process, of which he gives merely the results, was content with stating the ratio of the diameter to the circumference of a circle as intermediate between that of 7 to 22 and of 71 to 223, differing therefore by a 1200th part from the truth; whereas the chords computed by the astronomer of Alexandria for every half degree of the semicircle are correct to the last place, and consequently never deviate by a 300,000th part of the whole.

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with the tedious and operose methods of calculation then practised among engineers, he sought to shorten the road by recurring to general principles and the aid of Geometry. Thinking closely on that subject, he matured a regular system, which has changed the theory of planes and solids. The ardour of his pursuits was infused into his pupils, and the frequent communications he made to learned societies rapidly extended his fame. In 1780 he was conjoined with Bossut as acting professor of Hydrodynamics at the Louvre, a place erected by the patriotic minister Turgot, which required him to reside at Paris only during half the year. But three years afterwards, on being appointed to succeed Bezout as Examiner of the Marine, he fixed his permanent abode in the capital, and engaged in the experiments and discussions of the philosophers. He became a warm partisan of the Revolution, and contributed his utmost efforts to promote the various plans adopted by its leaders. But he deserved praise for the great concern he took in founding the Polytechnic School, an institution eventually productive of the very best effects. Having accompanied Bonaparte to Egypt, he returned with the fruit of his observations to share in the fortunes of that wonderful man. He resumed with lustre the place of professor, and continued to delight the numerous pupils by his kind attention and the clearness and expansion of his oral discourses. But on the second return of the Bourbons in 1815, he felt the weight of their vengeance. The Institute was remodelled, and the Polytechnic School suppressed. This sad reverse preyed on his spirits, and produced alienation of mind; in which melancholy state he languished for some time, and expired on the 28th July 1818.

The Romans, who cared only about objects of vulgar ambition, overlooked the refined mode of Greek Notation, and remained satisfied with their own very clumsy and involved system, which could with difficulty represent a large number, but was absolutely disqualified for serving in any way the purposes of calculation. They were obliged therefore to have recourse to counters, and by help of the *Abacus*, or decimal board, they performed the ordinary operations of summing accounts. This humble expedient was practised in Europe till the seventeenth century, and is still used by the traders throughout the Chinese Empire, its application being there facilitated by the prevalence of the decimal subdivision of weights, measures, and coins.

The discovery of the Denary Notation, so beautiful and simple in its application, is commonly referred to India, though neither the place nor the date of its origin has been ascertained. It was unknown to the Arabian astronomers till near the close of the eleventh century of our era, and even at this period its expressions appear sometimes intermingled with the alphabetic numerals. But the advantages of the system were soon perceived; and the Tables of Sines and Tangents calculated by those laborious mathematicians are now found, from examination of the manuscripts belonging to the University of Leyden, to be correct to the tenth decimal figure. The Arabians transmitted the new system of notation to the flourishing colony of their countrymen in Spain, whence it was slowly communicated to the several Christian States over Europe. This change was effected chiefly by the calendars or perpetual almanacs compiled in the Moorish seminaries, and eagerly purchased by the various monasteries and convents throughout Christendom. Yet the Arabic ciphers appear to have remained unknown in every part of Europe beyond Spain, before the middle of the fourteenth century; nor in mercantile transactions were they commonly adopted till near two centuries later. It is a singular circumstance that the advantages of employing the descending progression in the nicer calculations were not sooner perceived, especially after the use which Ptolemy had made of sexagesimals. Stevinus was the first who distinctly introduced the practice of decimal fractions in 1585, though Regiomontanus had made a great step towards that improvement, which Ramus even indirectly employed. To count downwards might seem as easy as to reckon upwards. But the mode of denoting the ranks of decimals was then most cumbrous, the successive numerals, like the indices in Algebra, being inclosed in small circles. Bayer in 1619 proposed to substitute for these complex marks an accent repeated. It was our illustrious countryman Napier, however, that brought the notation of decimals to its ultimate simplicity, having proposed in his *Rhabdologia*, printed ten years earlier, to reject entirely the marks placed over the fractions, and merely to set a point at the end of the units. But his sublime invention of Logarithms about this epoch eclipsed every minor improvement, and as far transcended the denary notation, as this had surpassed the numeral system of the Greeks.

Various speculations have been framed regarding the properties of the different arithmetical scales. Leibnitz fancied important advantages to accrue from the adoption of the Binary Scale, which operates with extreme facility, and requires only a single character besides the zero. This progression mounts so slowly, however, that it cannot express a large number without employing a multitude of terms. But the Duodenary Notation, which is partially admitted in the uncial subdivisions, would evidently answer the best for general practice. It proceeds faster than the Denary Scale, and is less subject to be affected by fractions, since its root has no fewer than four divisors, while *ten* admits only of two. Still these advantages would not compensate for its want of conformity with the train of ordinary language. The Decimal Arithmetic would soon generally supersede the use of every other kind of fractions, if it were likewise in practice combined with an extensive decimal subdivision of weights and measures.

The curious or mystical properties of numbers have at all times fixed the attention of mankind. Square numbers, denoting the sides of a right-angled triangle, were sought for by the Pythagoreans, who gave a very simple rule to compute them.[1] Perfect numbers, or such as may be composed by the addition of their aliquot parts, could not fail to excite admiration; and Euclid produced an elegant theorem for discovering them. It is remarkable that these numbers should appear frequent at first in the series, and afterwards occur only at wide intervals. Thus, below 10,000, there are four perfect numbers; but the last of the succeeding four includes no fewer than nineteen ciphers.[2] The moderns have advanced farther, and imagined what are called Amicable numbers, on all which subjects Euler has shown his ingenuity and unrivalled analytical skill.

It is less a matter of speculation, while it is of considerable consequence in the practice of calculation, to assign the Prime Numbers, or such as admit of no division, and to resolve the Composite Numbers into their several factors. No general method has yet been devised for the investigation of Primes, though by the researches of Bachet and Fermat in the seventeenth century, and of Euler, Lagrange, Legendre, and Gauss, in the eighteenth, they are now reduced to certain constant forms, which may facilitate their discovery. By an extension of the method called the *Sieve of Eratosthenes*, a sort of mechanical process, the prime numbers are separated from the ordinary progression. In this way several authors have constructed tables of Primes, and of Composite Numbers, with their various factors or divisors. Lindenau proceeded to a hundred thousand, but Cherac has lately carried the enumeration as high as ten millions.

The formation of Magic Squares, by which the numbers in their natural order are disposed in cells, so that each column gives an equal sum, remounts to high antiquity. They have been regarded in the east as charms or talismans, of great potency in the tide of human affairs. The digital squares from 3 to 9 were dedicated to the seven stars, including the sun and moon, which in the astrological visions were believed to rule the successive days of the week.[3] The people of Siam had learned a very simple method of filling up those squares; but some European Mathematicians have since amused themselves with such arithmetical curiosities. Stifels, in his *Arithmetica Integra*, incidentally treated of Magic Squares, yet without naming them. He was immediately followed in a small arithmetical treatise by Adam Riese; but the French seem to have directed most attention to those scientific recreations. From the latter part of the 17th till beyond the middle of the 18th century, a succession of ingenious persons were at pains to improve and extend the construction. Frenicle, Poignard, Delahire, Ons-en-Bray, and Rallier des Ourmes, are entitled to particular notice.

The construction of Magic Squares belongs to the class of problems styled Indeterminate, which depend on variable combinations, and therefore admit of very numerous answers. Thus, Frenicle, who successfully studied this subject near the beginning of the last century, showed that the first sixteen of the natural numbers could be formed into a Magic Square in not fewer than 880 different ways. Analysts have since tried to narrow those changes, and augment the difficulty of the investigation, by annexing other conditions. Dr Franklin produced, by dint of perseverance, what he called a Magic Square of Squares, and a Magical Circle. De la Hire[4] treated the formation of Magic Squares with such copious detail as to leave very little to be done by his successors. Yet several eminent mathematicians have occasionally reverted to this amusing subject. Even the great Euler has not disdained to direct his transcendant skill in algebraic analysis to the solution of problems connected with the theory of Magic Squares.[1]

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[1] See notes to the *Elements of Geometry*. Euler has demonstrated that every number whatever consists of not more than four squares. An example may be given of the composition of numbers between 10 and 20: $10 = 9 + 1$, $11 = 9 + 1 + 1$, $12 = 9 + 1 + 1 + 1$, $13 = 9 + 4$, $14 = 9 + 4 + 1$, $15 = 9 + 4 + 1 + 1$, $17 = 16 + 1$, $18 = 16 + 1 + 1$, $19 = 16 + 1 + 1 + 1$, $20 = 16 + 4$.

[2] It may gratify the curious to see the series 6, 28, 496, 8128, 33550336, 8589869056, 137438691328, and 2305843008139952128. These numbers are obtained by multiplying the 1, 2, 4. 6, 12, 16, 18, and 30 powers of 2 by its 2, 3, 5, 7, 13, 17, 19, and 31 powers diminished by unit.

[3] The first in modern times who noticed Magic Squares was Agrippa of Nettesheim, who gave in his books *de Occulta Philosophia*, printed in 1535, the *Sigilla Jovis*, *Martis*, *Solis*, *Veneris*, *Mercurii*, and *Lunæ*.

[4] Born at Paris in 1640, and died in 1718, a man of some attainments, and great application—well acquainted with the details of surveying, and of practical astronomy.

Another portion of Arithmetic, not merely curious, but of material importance in the application of that science, has been much cultivated during the eighteenth century. If both the terms of a proper fraction be divided by the numerator, there will result an equivalent fraction, having unit for its numerator, and an integer, conjoined with another fraction of smaller terms, for its denominator. But this new fraction may be again broken down in the same way, and the process of decomposition renewed successively, till a fraction with an integral denominator is at length obtained. This mode of resolution is therefore the very same as what is employed in finding a common measure or divisor, only the several quotients are here preserved. When the original fraction is expressed by rational numbers, its decomposition must always terminate; but if the numerator and denominator be mutually incommensurable, the process of evolving their elements will never draw to a conclusion. The fractions which thence arise may simply repeat, or they may circulate at short intervals or periods, or they may succeed each other without any sort of order whatever. But it is evident that such progressive subdivision must approach constantly nearer to the true value, and that the resulting fractions, if successively recombined, will exhibit a series of approximations.

The fractions of this kind were first noticed by Lord Brounker,[2] who proposed one of them to express the ratio of the diameter to the circumference of a circle, which Dr Wallis[3] afterwards investigated. Huygens perceived the utility of employing such fractions to represent approximate ratios, and in this way he found convenient small numbers to represent the teeth of the wheels and pinions of his Planetarium. But the subject appears to have lain neglected till 1737, when Euler explored it with his usual depth and felicity, in a distinct memoir published in the *Petersburg Transactions.* He may consequently be regarded as the real founder of the Theory of *Continued Fractions*, to which indeed he gave the appellation they have since retained. It was a favourite speculation of that great analyst, who resumed the subject at different times, and widely extended its application. Euler showed how to convert any quadratic equation into a Continued Fraction, and demonstrated that the expression for an irrational square root consists of terms which either repeat or circulate in regular periods. A cube root may likewise be expressed by a Continued Fraction, but its terms can have no sort of order in their sequence. As these Fractions, in approaching to their ultimate value, oscillate continually between excess and defect, they are always capable of being changed into Converging Series, affected by the alternate signs of *plus* and *minus*, and the transformation may be reversed. By this method the very ingenious Lambert converted the series of Gregory and Leibnitz for the length of a quadrant into a Continued Fraction, whose terms have a regular and incessant circulation, and hence proved (what had only been presumed before) that the Circle is incommensurable. But he was enabled to proceed still farther, and to establish, that even the square of the number expressing the circumference is likewise irrational.[1]

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[1] Cornelius Capito printed, in 1767, at Glückstadt, a short treatise on Magic Squares, in which he proposed to vary their construction no fewer than a million times. But the latest and completest work on this curious subject was compiled by the late Professor Mollweide of Leipsic, the ingenious editor of Klügel's valuable *Mathematisches Wörterbuch.*

[2] Born in 1620, and died in 1684; an able mathematician, but an unprincipled courtier.

[3] This very remarkable man was born November 23, 1616, at Ashford in Kent—educated at Cambridge—became chaplain to Lady Vere in 1643, and was then led to cultivate the art of deciphering, in which he acquired such skill, as to be afterwards frequently employed by the Long Parliament in examining intercepted dispatches. Through that interest he was appointed to a sequestrated church in London, and chosen in 1644 one of the scribes to the Westminster Assembly of Divines. But his austere occupation did not divert him from the nobler pursuits of philosophy and science; and being appointed by the Parliamentary commissioners in 1649, Savilian Professor of Geometry at Oxford, he continued regularly to discharge the duties of that office. He had afterwards some hot disputes with Hobbes, who, though a most ingenious metaphysician, unfortunately mistook his own blunders for discoveries in Mathematics. Wallis maintained a large correspondence with men of science, and assiduously contributed to the progress of philosophical discovery during that active period. The moderation of his character assured him the possession of the places he held at the Restoration; and though he found leisure to compose a very learned philosophical grammar of the English language, and sometimes indulged his early taste for controversial divinity, he devoted the greater part of a long life to the laborious cultivation and extension of the various departments of Mathematical Science. His works are voluminous, and display great erudition, talents for deep research, and originality of conception. He died on the 28th October 1703, and was succeeded in the chair by Dr Halley.

Lagrange has since recommended and explained the application of Continued Fractions to the solution of numerical equations. These fractions may be readily changed into Recurring Series,[2] which, in the case of small roots, are often beautifully simple and remarkably convergent. But sometimes they betray the opposite tendency to diverge; and the great object of Langrange was to remove that defect. Euler, in several of his last memoirs and opuscules, directed them to indeterminate problems, to the finding of *maxima* and *minima*, and to the development and integration of certain analytical formulæ. Nothing can exceed the beauty of some of these speculations.

It is a singular fact, that though Continued Fractions had their origin in this island, they were afterwards almost wholly overlooked by our mathematicians. Scarcely thirty years have passed away since the attention of the curious was again recalled to them. But an acquaintance with the transformation of those fractions would prove extremely useful to practical men, by furnishing a variety of short approximations, which are easily remembered and readily applied. Ordinary computations in mensuration, in the comparison of different weights and measures, and in several standard proportions, might thus be much abbreviated without any sensible inaccuracy. The method proposed by Lambert for decomposing fractions into progressions that have their denominators formed by successive multipliers, could be employed in a similar way; but its application is somewhat difficult and intricate.[3]

To facilitate the operations of arithmetic, tables have been digested of the powers and products of numbers. The most astonishing work of that kind, including all the multipliers from one to one thousand, was produced by Hervart, Chancellor of Bavaria, in 1610, only four years before the invention of Logarithms, the want of which it could in some faint degree have supplied. But tables of products in a less unwieldy shape are still occasionally used for abridging the labour of calculation. A notable improvement has been lately introduced by the substitution of Quarter Squares, grounded on the known property that the product of any two numbers is equal to the fourth part of the excess of the square of their sum above the square of their difference. A single page might comprise as many of those numbers as, by simple addition and subtraction, would exhibit an extent of products equal to those contained in Hervart's enormous folio.[4]

It would be a great improvement in elementary education to introduce into the schools a more extended multiplication table, including at least all the products of the numbers from 1 to 25. A very useful practice has been adopted lately in the north of Germany, to accustom learners to the readiness of mental calculation.[5]

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[1] The area of a circle having unit for its diameter is expressed by the alternating series $1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9}$, &c. which was converted by Euler into the continued fraction

$$\cfrac{1}{1+\cfrac{1}{2+\cfrac{9}{2+\cfrac{25}{2+\cfrac{49}{2+\text{\&c.}}}}}}$$

the numerators being the squares of the odd numbers. This extension never stops, and consequently the fraction is not reducible to finite terms. The square of the expression runs into a similar infinitude.

[2] It deserves to be mentioned that Girard first gave the simple recurring series which expresses the parts of a line divided into extreme and mean ratio. It is formed by the continued addition of the two preceding terms. Thus 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, &c. The square of each number in this series differs from the product of the two numbers which inclose it, only by unit alternately in excess and defect: Thus $8^2 = 64 = 5 \times 13 - 1$, $13^2 = 169 = 8 \times 21 + 1$.

[3] For an explication of Lambert's method of decomposing fractions, see *Philosophy of Arithmetic*.

[4] A large table of multiplication, from 1 to 10,000, and a specimen of quarter squares, extending to a million, may be seen in the treatise quoted above.

[5] It is called *Kopfrechnung* or *calculating by the head*. Three works are current on this subject, those of Biermann, Heuss, and Köhler—published between 1790 and 1816.

3. ALGEBRA.

Algebra derives its immense superiority over the ancient analysis from the very complete system of notation which it has at length attained. Each step of an investigation being now registered in the clearest and most precise manner, the mind is relieved from the fatigue of carrying forward the whole of a continuous chain of reasoning. It can rest at any place; and again resume the process of deduction with the greatest facility. But this perfection of pictured language has been the result of a series of slow and successive improvements. Diophantus, who, soon after the Christian era, composed a large treatise on the resolution of certain arithmetical problems, a portion of which work is preserved, made the first attempt towards an abbreviated form of analysis. The symbols he used were, however, exceedingly few, being the initials or terminations of the ordinary words, only somewhat modified. It deserves remark, that Diophantus viewing a number as composed from another by the addition or subtraction of a third, he termed this last one *abundant* or *deficient*, and gave a rule for the multiplication of those affected numbers, similar to what is now applied to the signs *plus* and *minus*. His treatise passed into the hands of the Arabians, who studied the numerical properties with much ardour, but made no advances in refining or simplifying the form of notation. From them again this higher species of arithmetic was transplanted into Italy, probably during the fourteenth century, by Leonard, a merchant of Pisa, who had travelled long in the East. A series of works on Arithmetic and Geometry were published between the years 1470 and 1487 by Pacciolo, a Minorite Friar, who in 1494 brought out his *Arte Maggiore*, or what he says was vulgarly called the *Regola de la Cosa*, or *Alghebra and Almucabala*, the first appellation derived from the Italian *Cosa*, denoting the *Thing* sought, and the other borrowed from the Arabic words expressing *Resolution* and *Composition*. After the appearance of this elementary digest, Algebra was cultivated in Italy, during the first half of the sixteenth century, with great industry and success. Ferreo, Tartalea, and especially Cardan, made rapid advances in the new science. This ingenious though very singular person not only gave the solution of Cubic Equations which bears his name, but discovered the leading properties of equations in general, distinguishing their roots into the *true* and the *fictitious;* and besides improved the notation by employing frequently the letters of the alphabet. The Italians, however, still used contracted words for symbols, and the initials *p.* and *m.* for the signs of *plus* and *minus*. In 1572, Bombelli of Bologna, retaining this embarrassed mode of writing, composed a regular summary of Algebra, which he enriched with Ferrari's rule for resolving biquadratic equations. In the meanwhile the knowledge of the analytic art had penetrated into Germany, where it received its capital improvement in notation from the systematic genius of that people. The change was chiefly effected by the industry of Stifels,[1] a Protestant minister and zealous follower of Luther, who in 1544 published his *Arithmetica Integra*. In that remarkable work he first introduced the symbols + and — for *plus* and *minus*, and the character √ (or a contracted R) for *Radix* or *root;* and he represented unknown quantities by the capital letters A, B, C, &c. and intimated the successive powers and their reciprocals by an ascending and descending series of *exponents*. Nor was his merit confined to algebraic writing: the enthusiasm of the age seems to have roused the spirit of invention in him; and Stifels anticipated some of the later discoveries, pointed out the nature of Logarithms, explained the properties of figurate numbers, and showed how the co-efficients of the powers of a binomial quantity may be derived from the columns of what has been since called the arithmetical triangle. Scheubel a few years afterwards pursued the same path, yet without adding any thing material to the science. In this state it made its way at last into England, where Recorde,[1] an ingenious though unfortunate man, printed the *Cossic Art* at London in 1553. He was the first to propose the sign = for equality, but made no other advances; and during a period of most active enterprise, till the close of the century, Algebra was not cultivated at all in this country.

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[1] Born at Eslingen, in Saxony, in 1509, and died at Jena in 1567. Though a profound and inventive mathematician, he seems to have imbibed all the wild enthusiasm of that convulsed period. Captivated perhaps by the wonderful properties of numbers, he fancied, as other ingenious persons have since done, that he could interpret the visions of the Apocalypse, and foretell the end of the world. He was so imprudent as to place that awful dissolution very near hand. Early in the morning of the day predicted in the year 1553, he assembled his trembling flock in a wide open field, where he endeavoured to season their minds for the tremendous change by fervid prayers and pathetic exhortations. The sky was lowering, the darkness thickened, a portentous silence prevailed, and the preacher rolled his thunders with overpowering energy. But the clouds soon passed away, the sun shone forth in his wonted splendour, and all nature smiled. The populace recovered their agitated spirits; and now breathing rage and disdain, they chased the unlucky prophet home with volleys of stones.

In the meanwhile France continued the pursuit of the mathematical sciences. Ramus had revived those abstract studies; but Vieta, who succeeded him, and flourished between the years 1570 and 1600, rose by his numerous discoveries to much higher eminence; a lawyer by profession, yet a man of great learning, and gifted with profound and original genius, conjoined with the most indefatigable application. Vieta introduced the literal or *specious* Algebra, and thus rendered its procedure quite general, by employing the Roman capitals always to denote numbers, the vowels being appropriated to unknown quantities. He likewise traced various distinctions, and framed several significant terms, which are still retained. But while he improved the analytical symbols, he greatly extended the theory of equations, and cultivated with success the prolific and important subject of angular sections.

Flanders at this period equally displayed the spirit of invention. Stevin of Bruges, born about the middle of the sixteenth century, was an engineer eminently skilled both in the theory and practice of his profession, possessing great original powers of mind. He reduced Statics and Hydrostatics to their simplest principles; and in his Arithmetic or Algebra, printed in 1585, he extended the range of calculation by several fine improvements and discoveries. Marking the unknown quantity with a small circle, he denoted its power by inserting the index; and was enabled, by prefixing a fraction, to represent also the roots. But, besides improving and simplifying the symbols, he enriched the analytic art by his inventions, and gave a general method for the resolution of numerical equations. The works of Stevin were, in 1625, collected and expanded by his countryman Girard,[2] a man likewise of most original conception, who eagerly promoted the objects of science. Four years afterwards this editor produced a small tract exclusively his own, and full of new and ingenious deductions. He there gave a very complete theory of equations, distinguishing them into their several orders, and proving that they had always a corresponding number of roots; he showed how these roots are successively combined in forming the co-efficients of the several terms; and finally anticipated the remarkable rule discovered by Newton, to find the sums of their different powers. Girard was possessed of fancy as well as invention; and his fondness for philological speculation led him to frame new terms, and to adopt certain modes of expression which are not always strictly logical. Though he stated well the contrast of the signs *plus* and *minus*, in reference to mere geometrical position, he first introduced the very inaccurate phrases of *greater* and *less than nothing*, and began the unfortunate appellation of *impossible quantities*.

It is indeed the reproach of modern analysis to be clothed in such loose and figurative language, which has created mysticism, paradox, and misconception. The Algebraist, confident in the accuracy of his results, whenever they become significant, hastens through the successive steps to a conclusion, without stopping to mark the conditions and restrictions implicated in the problem. This rapidity of operation, though in many respects most advantageous, yet affords less mental exercise than the cautious and guarded procedure of the Greeks. It will not be deemed foreign to the scope of this discourse, to remark, that the signs *plus* and *minus* confer no distinctive character, but merely indicate that the number to which they are prefixed, is to be *annexed* to some other number, or *disjoined* from it. The terms *additive* and *subtractive* would express correctly their whole import. The rules for the involution of those signs are derived from the consideration of the properties of compounds, arising from the addition or multiplication, for instance, of the binomials $a \pm b$ and $c \pm d$. The operation proceeds by detail; but the real meaning of the notation may be suspended, and it becomes significant only after the several members have been recombined. A *number*, in strict language, is altogether devoid of quality, and can be reckoned neither *positive* or *affirmative*, nor *negative*, which designations are *accidents*, and not *attributes.*[1] In proposing these terms, Vieta did not, therefore, discriminate the precise nature of the symbols; and his powerful example has continued to infect the language and darken the conceptions of algebraists. A disposition has also prevailed in modern times, of hastening to general conclusions, although the data be limited or imperfect. Such careless deductions are but awkwardly amended, by the adoption of expedients more like the fictions of lawyers than the reasonings of sound logicians. The introduction of equal and impossible roots of equations served only to restrict the ordinary rules, which had been made too general, representing the number of roots as *always* equal to the index of the highest power. The involution or repeated multiplication of binomials will produce the successive orders of expressions, which pass into equations on the supposition that any one of them vanishes or has its parts mutually balanced. But the converse of this proposition will not always hold true, That every compound expression is resolvable into as many binomial factors as the index of its highest power signifies. Several forms even of the quadratic or cubic expressions resist all binomial decomposition. But it is a property demonstrated, that every higher expression whatever may be resolved into binomial or trinomial factors, or into simple or quadratic elements. *Impossible quantities* are thus merely the symbolical exhibition of the binomial factors of a quadratic or trinomial expression which is irreducible; and the mark of impossibility is removed, either by a change of the signs, or by a recombination that restores those factors to their primitive binomial form. Such notation may indicate the limits of a problem, and seems to originate in neglecting the previous statement of the limitations.[1] In reference to Geometry, the impossible expressions intimate the transition of the circle into the equilateral hyperbola, or of arcs into logarithms.

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[1] Robert Recorde, born of a good family in Wales, about the year 1506—studied at Oxford, and elected a fellow there in 1531. He embraced the medical profession, but taught mathematics at both universities, and afterwards in London, where between the years 1551 and 1557 he published several elementary treatises on Geometry and Algebra, with quaint titles But Recorde was unfortunate, and having been thrown into the Fleet for debt, he died a prisoner in 1558.

[2] Albert Girard published his edition of Stevin's Arithmetic in 1625, and his own discoveries in Algebra in a small quarto at Amsterdam in 1629. He died in 1633, and his widow the year after put forth his complete collection of Stevin's works.

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[1] This distinction might perhaps have satisfied the scruples of the late venerable Baron Maseres, who wrote an express treatise against the abuse of the *Negative Sign*, which he came to view with a sort of aversion as the main source of the incorrect language and vague conception so prevalent among algebraists. Though not quite entitled to the rank of a discoverer, that excellent person deserves a place in the history of Mathematics, for his valuable contributions, and his zealous and unwearied exertions to promote accurate science. He was an able geometer, a profound constitutional lawyer, a man of sound and most extensive learning, and of very general information. But he possessed the higher qualities of our nature, and combined liberality of sentiment and unbending integrity with the feelings of a kind, generous, and social disposition. His *Elements of Trigonometry* was the completest treatise in English at the period of its appearance. He afterwards improved the solutions of cubic and biquadratic equations, and illustrated the methods of approximating to the resolution of equations in general. But the most important service he rendered to mathematical science consists in reprinting at great expence, and chiefly for distribution, the series of original authors in logarithms, with ample annotations, in six large quarto volumes. From his anxiety to be perspicuous, he was apt to fall into the opposite extreme of tiresome prolixity.

The grandfather of Maseres was an officer in the French guards, born in the district of Bearn, and a Hugonot, who, on the revocation of the Edict of Nantes, retired to Holland, and transferring his services to the Prince of Orange, accompanied the Preserver of our liberties into England, and fought by his side in Ireland. The grandson having embraced the profession of the law, was soon after the peace of 1763, probably on account of his intimate acquaintance with French language and customs, appointed Attorney General of Quebec, where he resided till 1770. At leaving his charge, he visited Boston and New York, while that agitation was fermenting which burst into open revolt. Soon after his return to England, he published in successive volumes his *Canadian Freeholder*, in which he refuted the despotic maxims of Lord Mansfield, and earnestly recommended conciliatory measures with our American colonies. But it was a time of infatuation and disaster. Maseres by his firmness gave mortal offence to the courtiers, and never obtained any promotion, farther than the small sinecure office of Cursitor Baron of Exchequer. But fortune had abundantly provided for all his wants, and he enjoyed unbroken health, and the renovating pleasures of study and social intercourse. The Baron had composed a full and learned treatise on Life Annuities, and matured a plan for securing small pensions from Government to such of the poorer classes as should make certain contributions during the vigour of their days. This he embodied in a Bill which passed the Commons, but was lost in the House of Lords, through the influence of the Bishops, who seem to have considered pauperism as a right appendage to their splendid ecclesiastic establishment. He died at Reigate in May 1824, at the very advanced age of 93.

The publication of the Geometry of Descartes in 1637 is justly deemed an epoch in the history of analytical science. The capacious mind of the author seized on all the preceding discoveries, and moulded them with his original inventions into a regular and comprehensive system. He gave rapidity to the writing of Algebra by the introduction of small characters, and rendered the distinction more palpable between known and unknown quantities, by the appropriation of the initial and final letters of the alphabet. He adopted the notation of the integral exponents or indices, as reduced to its simplest form by Herigon; and this apparently very slight improvement led, in the sequel, to the most important results. Though the index was at first merely a contraction for the repeating of the same letter in the involution of powers, yet it acquired a most extensive import when it came to be treated abstractly as a number. The prefixing of the subtractive sign changed the expression into its reciprocal, and the substituting of a fraction converted it into the symbol of evolution or the extraction of roots. Nothing can better illustrate the efficiency of a systematic notation, as an instrument for enabling the intellect to pursue and generalize its deductions, than the successive modifications which analogy suggested in the marking of exponents, during the short period from Descartes to Newton.

But the French philosopher effected a revolution in scientific procedure, by applying (what his countryman Vieta had only partially attempted before) the symbols and calculations of Algebra to the solution of geometrical problems. By referring curve lines to co-ordinates or mutual perpendiculars, he expressed their relations by equations, of which he distinguished the rank and composition. He showed that a biquadratic equation is, by the help of indeterminate co-efficients, resolved into two quadratics, and may be constructed by combining a circle with a conic section. The construction of a cubic equation was somewhat simpler, though derived from the same principles. But Descartes proceeded still farther, and represented what are now called curves of double curvature, by reducing them, by a series of perpendiculars, to some plane of projection. These were all important advances in mathematical speculation.

Attempts have been made to apply the Cartesian method even to Elementary Geometry, which is in fact to convert a clear and simple train of reasoning into a sort of hard mechanical process of calculation. This change, were it attainable, would be the reverse of an improvement. It would extinguish that fine study which affords the best exercise and discipline of the intellectual powers. The wonderful dexterity and readiness which men of such teeming invention as the Bernoullis, Euler, and Lagrange generally displayed in managing algebraic analysis, appear to have seduced their admirers into an over-estimate of its real advantages. The constructions derived from algebra very seldom reach the purity and elegant simplicity of the geometrical methods. In those cases where Geometry is most felicitous, they betray the features of a clumsy and artificial combination. The application of Algebra should therefore be reserved for the most arduous and complicated problems in the Higher Geometry.

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[1] A very simple problem will illustrate this: Suppose it were required, from a given point, to draw a tangent to a given circle. The construction would be, to join the centre with the given point, and upon the connecting line describe a circle to cut the former in the points of contact. It is evident, that if the given point occupied the extremity of the diameter, there would be only one point of contact; and if it lay within the circle, there could be none. This construction hence intimates sufficiently the conditions of the problem; and yet it fails in the case where the circle described merges in the given point, and consequently ceases to determine the position of the tangent. The algebraical solution, if rightly interpreted, gives similar information. Let r denote the radius of the given circle, and a the distance from its centre to the given point; then $\sqrt{a^2 - r^2}$ will express the length of the tangent, which only requires to be inflected to the given circumference. But if the given point fall on that circumference, then $a = r$ and the origin and termination of the tangent coincide, leaving its position undetermined. Again, if the given point lie within the circle, a will be less than r, and consequently the subtractive portion $-r^2$ will predominate over the other portion a^2, and the compound radical $\sqrt{a^2 - r^2}$ become impossible. It serves to show, however, that by a change of condition the problem would be rendered soluble.

In the latter part of the seventeenth, and during the course of the eighteenth century, Algebra still continued to advance; and though it underwent no revolution, it acquired greater perfection in all its details. The construction of cubic and biquadratic equations, which Descartes had effected by combining a circle with a parabola, was afterwards improved; but Newton proposed the *Conchoid* as the curve best adapted for the practical solution of such problems. Leibnitz succeeded in conquering the irreducible case of Cardan, by a bold application of the binomial theorem, having converted the cubic roots of the compound expressions into two series, with alternate imaginary terms, which are extinguished by their conjunction. In examining generally the nature of cubic equations, their solution came afterwards to be referred to the trisection of a Circular or Hyperbolic Sector, and was therefore accomplished by the application of a table either of Sines or of Logarithms. The theory of the Section of Angles and of Ratios, founded by the ingenuity of Cotes, furnished a clue to the resolution of certain forms of the Higher Equations. But though Euler solved biquadratics in a different way from that of Descartes, all attempts to find directly the roots of the fifth and the superior orders of equations had totally failed. It became necessary therefore to have recourse to the approximative methods of resolving equations. Successive improvements in the process of calculation were made by Raphson, Halley, Lagny, and Taylor; so that little seemed wanting for any practical end.

During the last century likewise the method of series, so various and extensive in its application, was cultivated with the greatest success. About the years 1714 and 1718, Montmort[1] and James Bernoulli employed it in the investigation of the Laws of Chance. But De Moivre,[2] a French refugee, and a man of learning and profound science, carried these researches much farther, having devoted his time professionally to the calculation of probabilities, and of the values of life-annuities. In 1730, he published an original work, which, besides other useful inventions, explained the properties of a *Recurring Series*, that always repeats the same succession of co-efficients in distinct sequences. About the same time, Stirling[3] brought out a complete treatise on Series, in which he advanced by a different road to consider their convergence, interpolation, and summation. This ingenious mathematician followed no general procedure, but showed great felicity and address in transforming one series into another. The subject was at different times partially extended by Simpson, Maclaurin, Landen, Lorgna, Hutton, Waring, Pfaff, and Kramp. Euler handled Series with his usual fulness, perspicuity, and penetration; and yet Lagrange and Laplace, in surveying that field, have gleaned fresh discoveries, which the latter of these illustrious men applied most happily to develope the Theory of Probabilities.

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[1] A man of some rank, and an able mathematician, born in 1678 at Paris, where he died in 1719.

[2] Abraham De Moivre, born in 1667 at Vitri in Champagne. Being a Protestant, he was obliged at the age of eighteen to seek shelter in England after the revocation of the Edict of Nantes. Having shown an early taste for Mathematics, he continued to prosecute the study as a profession. He supported himself creditably in exile, by giving lessons and reading public lectures. His analytical discoveries extended his fame, and his good conduct insured him respect. He embraced the Newtonian Philosophy, and made some improvements on it. He generalized Cotes' famous theorem of the section of a circle, but turned his attention chiefly to the method of series, which he applied successfully to the doctrine of annuities and chances. After his reputation for such calculations had been established, it is said that he spent a great part of the day at Slaughter's Coffee-House, in St Martin's Lane, where he was ready to answer any question of that nature propounded to him, for the fee of one guinea. His principal work on the *Doctrine of Chances* was published in 1738, but the enlarged and improved edition bears date 1756. De Moivre lived to a great age, but in his advanced years he was subject to obstinate fits of sleeping, and in that torpid state he remained for at least several weeks, till death closed the scene in November 1754.

[3] James Stirling, born about the year 1690 in Stirlingshire, where his father owned a small property. He was educated at Glasgow, and sent by that University on Snell's Foundation to Baliol College in Oxford. During his retreat there he applied himself so diligently to the study of Mathematics, that he printed in 1717 a small tract on Lines of the Third Order, with new solutions of one or two difficult problems by the fluxionary calculus. He then repaired to London, and becoming acquainted with the Venetian Minister, he accepted an invitation to settle at Venice, where he resided several years, and taught Mathematics. The vicinity of Padua gave him an opportunity of acquiring the friendship of Nicholas Bernoulli, nephew of the two elder Bernoullis, who was Mathematical professor in that University. During his stay at Venice, Stirling contrived to gain access to the manufacture of glass plates, and escaping at some personal risk, he is said to have transferred the secret to England. He now conducted a mathematical or nautical school on Tower Hill, while he maintained a correspondence with the philosophers both abroad and at home. Here he published his great work on the *Differential Method and Series* in 1730. After toiling in his academy several years, he was induced to leave London, and undertake the direction of the Mines at Leadhills in Scotland. In that elevated district near Sanquhar he resided during the rest of his life, and by his skill and activity he greatly improved the operations of extracting the lead ore. He now held a profitable employment, but his high mathematical fame would have secured him the honour of succeeding Maclaurin in 1746, if he had not at that unhappy period been tainted with Jacobite principles. In his latter years he seems to have confined his attention to practical concerns, and died at Leadhills in 1772.

The composition of equations was at the same time investigated with more address and precision. The rule for distinguishing the positive and negative roots from the alternating signs, which Descartes had merely stated, now received a strict demonstration by Segner. The mode of finding the impossible roots, or rather the quadratic factors, of an equation, which Newton probably had inferred from mere induction, was traced by Maclaurin to its real source. D'Alembert proved that every irrational expression is reducible to the form $A^2 \pm \sqrt{-B^2}$; or, in other words, that every compound expression of a higher order may be resolved either into simple or quadratic factors. This is the most important conclusion perhaps relating to the nature of equations. But the general theory was never so clearly and completely discussed as by Gauss, in a small work published by him in 1779. Various methods, and several of them elegant, have been proposed by Euler and others for simplifying and expediting the approximation to the roots of equations. When a question involved the powers and products of more than one unknown quantity, it exercised the skill of algebraists to separate them; but Bezout[1] has brought the mode of this *elimination* into a regular system, which removes all the difficulties. Among the promoters of Algebraical Science may be ranked our countryman Dr Waring,[2] a profound analyst, but unfortunately an obscure and confused writer. His *Miscellanea Analytica* and other detached pieces discover uncommon penetration and originality of conception, and though neglected at home, they have, notwithstanding their repulsive form, been duly appreciated by the great mathematicians on the Continent.

The latest improvement that Algebra has received consists in the *Combinatorial Analysis*, which may be viewed as an important extension of the principles of the binomial theorem. Vieta traced the rudiments of the doctrine, which was successively enlarged by Mersenne, Guldinus, Schooten, Pascal, Wallis, James Bernoulli, De Moivre, and Euler. But it has received its greatest expansion in Germany, and chiefly from the laborious and persevering researches of Hindenburg, who first published a tract on this subject in 1779, and resumed the discussion in the years 1793, 1794, and 1795. He was followed in the same line of investigation by Burckhardt, Rothe, De Prassi, and Pfaff; and this interesting branch of analysis now forms a part of the algebraical course pursued in the German States. It throws much light on the theory of equations, renders more general the method of series, and facilitates the calculation of chances.

In the application of Algebra to Geometry, Euler, pursuing the route marked out in 1727 by Frederick Mayer, has given such extension to the properties of Angular Sections, as to create almost a new science, bearing the appellation of the *Arithmetic of Series*. Vieta prepared the way, and the Bernoullis had advanced far in the research, but it was reserved for their great disciple to expand and convert their conclusions into a compact body of doctrine. This important branch of Analysis has continued to be much cultivated in Germany, under the more expressive name of *Goniometry*, which was first applied by Lagny in the Parisian Transactions for 1724, to an ingenious method proposed by him for measuring angles.[1] Pfaff has lately enlarged it with the properties of the multiple tangents, and his countryman Mollweide has likewise made some valuable additions. The store of *formulæ* now collected is of the utmost utility in transforming and reducing into practical operation the different series adopted by Physical Astronomy.[2]

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[1] Stephen Bezout, born at Nemours on the 31st March 1730—led accidentally to the study of Geometry, and fired by the perusal of the *Eloges* of Fontenelle. Having soon distinguished himself by proficiency in Mathematical Science, he was appointed Examiner to the Navy in 1763, and Examiner of the Artillery Department 1768. In the discharge of his duty in those offices, he gained the love and respect of the youth by his impartiality, kindness, and solicitude for their advancement. He published *The General Theory of Equations* in 1779, and gave further proofs of his original inventive powers in other occasional Memoirs. But he has owed his celebrity chiefly to the excellent *Course of Mathematics* compiled for professional education, which is highly esteemed and generally adopted on the Continent. The constitution of Bezout was prematurely exhausted, and he died of a malignant fever on the 27th of September 1783.

[2] Edward Waring, born near Shrewsbury in 1736. He studied at Cambridge, where he distinguished himself so much in abstruse calculations, that he was elected, after a hard contest, Lucasian professor of Mathematics in January 1760. He led the life of a recluse student, and though a man of great worth, he was unfitted by his extreme diffidence for the general intercourse of society. His latter years appear to have been spent at his place of nativity, where he died on the 15th August 1798. Waring had not entirely confined his application to mathematical research; he printed a metaphysical tract of considerable merit, which was distributed among his friends; and it deserves mention, that he there distinctly brought forward the philosophical view of Causation which is now very generally embraced.

Algebra has also been applied with advantage to Goniometry generally, as comprehending the solution of the cases both in Plane and Spherical Trigonometry. This was early attempted by Girard, but carried to its completion by Euler and Lagrange. Some concise and elegant formulæ have been deduced, which facilitate and diversify the practice of computation. In short, if Algebra were purged of the vitious language and inaccurate conceptions that pervade it, and which were early introduced by the confidence of rapid and careless calculators, it might at last claim the character of a perfect science.

The number of elementary treatises of Algebra which have been produced in various languages during the currency of the eighteenth century, appears quite incredible. They are almost ephemeral, and assume every feature and dimension, superficial or profound, from the size of a primer to the magnitude of a lexicon. A very few of those works claim the highest praise, and may retain their hold of education. The Algebra of Euler is in various respects a most remarkable production. That illustrious analyst, when totally deprived of sight in his advanced age, dictated it in the German language to a young domestic, whom he trained for an amanuensis. He was obliged therefore to be plain, distinct, and perspicuous; and these qualities he combined with richness of invention. The second volume had an air of originality, which made it peculiarly interesting. It treated of Diophantine Problems, and the resolution of Indeterminate Equations,[3] and was afterwards expanded in the French version by the masterly annotations of Lagrange. In our own language, Maclaurin's *Elements of Algebra*, though a posthumous work, is perhaps the ablest on the whole, and the most complete. The bulky volumes of Dr Sanderson,[4] which were likewise printed after the death of the author, are commendable chiefly as the production of an ingenious person, afflicted from infancy with the calamity of total blindness; they have little claims to depth, originality, or logical precision, but possess the merit of being eminently clear, methodical, and copious even to diffusion. The *Algebra* of Thomas Simpson is a work of an opposite description—brief, condensed, and marked with traits of invention. Passing over the numerous smaller treatises which have run through the schools, the compilation of Emerson[5] deserves notice. It forms part of the *Cyclomathesis*, or series of elementary works in all the departments of Mathematics and Mechanical Philosophy, executed with ability by that singular man; exhibiting a mass of valuable matter, clothed in a slovenly style, and digested without method, or any regard to taste or elegance. Nothing is more wanted for the purpose of education than a classical treatise on Algebra, which, avoiding all vague terms and hasty analogies, should unfold the principles with simplicity and rigid accuracy, and follow the train of induction with close and philosophical circumspection.

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[1] This consists in performing by the help of compasses a repeated decomposition, similar to what is effected in the reduction of a common to a continued fraction. There being in practice generally a balance of errors, the numerical relation hence derived approximates to great precision. The method may be applied to the comparison either of arcs or of straight lines.

[2] The collection of *formulæ* by Hirsch deserves particular commendation.

[3] A very simple and regular method of solving such questions is given in the second volume of the *Transactions of the Royal Society of Edinburgh.*

[4] Nicholas Sanderson, born at Thurleston in Yorkshire in 1682. When only twelve months old, he lost both eyeballs by small-pox; but showing early capacity, he was sent to the free-school at Penniston, where he made great proficiency in the knowledge of the classics, and soon understood the works of the ancient Geometers when read to him in the original Greek. He afterwards profited by the kind instructions of some mathematical friends, and found himself so far advanced in science, that at the age of 25 he repaired to Cambridge, and established his fame in that university by the warmth and splendour of his lectures on the Newtonian Philosophy. He was encouraged by the gentleness of Whiston, who saw no rival; and, on the ejection of that amiable enthusiast in 1711 for heresy or dogmatism, succeeded to the Lucasian Professorship of Mathematics, the duties of which he continued henceforth to perform with zeal and assiduity. The faculties of touch and hearing he possessed in a wonderful degree; and he was a lively companion, breathing a free and open disposition. But sedentary habits impaired his vigorous constitution, and he died of a mortification in his limbs on the 19th of April 1739.

[5] William Emerson, born in June 1701 at Hurworth, a village near Darlington—the son of a schoolmaster, who taught him Mathematics, and left him a small property, which he occupied and cultivated. He was a person of strong intellect

4. THE HIGHER CALCULUS.

Leibnitz, at his death, left the Calculus which he had framed in a most flourishing condition. The superiority of its algorithm, joined to the ardour of his disciples and successors the Bernoullis, gave it the complete possession of the Continent. But in England, the Method of Fluxions, now greatly in arrear, was cultivated only by a very few aspirants. Its inventor had vacillated about the notation he should adopt, and the unfortunate marking by points appeared the first time in one of the volumes of Dr Wallis' works, printed in 1699.[1] Newton had published nothing separately on the subject, till the Tract on *Fluxions*, drawn from the recesses of his closet, made its appearance in 1704; which, though full of ingenuity, was then decidedly imperfect and insufficient. But Cotes[2] and Taylor[3] laboured successfully in extending the analytical discoveries of their great master. The former, one of the brightest mathematicians whom England has produced, died at an early age, after achieving, however, some fine analytical discoveries. Besides producing the beautiful geometrical theorem on which is founded the application of Binomial Factors, he constructed an ample Table of Fluents or Integrals, which were solved by the decomposition of fractions, by Logarithms or Circular Arcs. Other ingenious problems are introduced in his posthumous volume entitled *Harmonia Mensurarum*, published in 1722 by his relative and successor Dr Smith; but for want of the author's revision, this profound tract is unluckily so concise and obscure as to need a commentary. Some of the propositions were neatly demonstrated by John Bernoulli; but De Moivre considerably extended the doctrine, which was afterwards reduced into a systematic form by Walmesley.

Dr Brook Taylor was a man of rich invention and elegant accomplishments, who supported with dignity the reputation of English science. He was indeed our only mathematician that,

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and considerable talent of invention; but affected singularity, and indulged coarse boorish habits. Having a mechanical turn, he constructed his own instruments, and delineated all the figures he wanted. His best work, perhaps, was the treatise of *Increments*, but his System of *Mechanics* has had the greatest currency among all ranks of students. In the decline of life he suffered much from the cruel attacks of gravel, and died after a lingering illness on the 20th May 1782.

[1] The earliest mode used by Newton for denoting a Fluxion seems to have been a zero prefixed to the variable quantity. Thus, the fluxion of x^n was written $n\,x^{n-1}\,o\,x$. It is evident therefore that the great inventor must have then had nearly the same conception of the origin of Infinitesimals as his rival Leibnitz.

[2] Roger Cotes, born July 10, 1682, at Burbach in Leicestershire, of which his father was rector. Having shown an early and decided inclination to Mathematics, he was encouraged by his uncle, the Rev. John Smith, who carried the boy to his house in Lincolnshire, and carefully instructed him in the principles of science. Hence he removed to St Paul's school, where he made great progress in classical attainments, but still found leisure to cultivate his favourite studies. Thus accomplished, he was sent to Trinity College at Cambridge, and advanced through all the gradations with unrivalled distinction. In January 1706, he was elected unanimously to the chair of Astronomy and Experimental Philosophy, which had been just founded by Archdeacon Plume. He took orders in 1713, and at the desire of Dr Bentley superintended the printing of the second edition of the *Principia*, to which he furnished a learned and ingenious preface. His genius and uncommon talents had raised the highest expectations, when a putrid fever snatched him away in the full tide of vigour, on the 5th of June 1716. Newton in his latter days used often to exclaim with a modest feeling of regret, "If Cotes had lived we should have known something." This very promising philosopher was perhaps rather fastidious; for, except a short but ingenious essay on Logarithms, he produced nothing of decided importance during his lifetime. The papers left by him in an imperfect and unfinished state were collected and published with some annotations by his cousin and successor Dr Robert Smith.

[3] Born in affluent circumstances at Edmonton in Middlesex in 1685; studied at Cambridge, where he distinguished himself, and passed through the successive gradations with the greatest applause. The mathematical and physical sciences were his favourite pursuits, but he embraced general learning and cultivated the fine arts, being especially fond of painting and music. Fortune enabled him to indulge his taste. He held the office of Secretary to the Royal Society for a few years, and afterwards visited the Continent. His mind was most acute and inventive; but, though methodical on the whole, he was at no pains to unfold his original conceptions. He died at an early age in 1731.

after the retreat of Newton, could safely enter the lists with the Bernoullis. His most original work, the *Methodus Incrementorum*, published in 1715, unfolded the elements of the increase and decrease of a variable quantity or function. It was a fine extension of the Differential or Fluxionary Calculus, and constituted a new and important branch of the Higher Analysis, which has since received an appropriate algorithm, and acquired the appellation of *Finite Differences.* The *Method of Increments* was applied to the summation of series, and a variety of difficult problems, of which it afforded easy and rapid solutions. It furnished the first investigation of the motions of a vibrating cord, showing that the harmonic curve is a Trochoid or Prolate Cycloid. Among other improvements, it contained the celebrated theorem for the expansion of a magnitude, arising from the combination of its successive orders of differentials, which has deservedly retained the name of its ingenious author. This elegant formula is of extensive use in almost every analytical inquiry, and even performs the inverse process of Fluxions, by exhibiting in many cases at once the resulting fluent or integral. But the notation employed was imperfect, consisting merely of accents instead of points; and the Tract, like other works of Taylor, affected a degree of brevity which borders on obscurity. It was therefore elucidated by Nicole, an eminent French mathematician, in a series of able dissertations, between the years 1717 and 1727. The Taylorian Theorem itself has been successively modified, transformed, and extended by Maclaurin, Lagrange, and Laplace, whose names are attached to their several formulæ.

The Italian mathematicians contributed materially to the progress of the Higher Calculus. The Integration of a class of Differential Equations was proposed by Count Riccati, and solved in different ways by himself and the sons and nephews of the first Bernoullis. Manfredi[1] in 1707 gave a skilful solution of differential equations of the first degree; and in 1722, Vincent, the son of James Riccati, pursued likewise the same road. A curious kind of problems was started by Fagnano,[2] another Italian Count, to determine those Elliptical or Hyperbolic Arcs, which have their difference expressed by an algebraical quantity. This led Euler, in 1756, to invent a very comprehensive method of determining particular integrals, that Lagrange improved in 1766 and 1769, and which he himself again simplified in 1778. Our ingenious countryman Landen has chanced to fall into a similar train, having in 1775 converted the formula for the rectification of the Hyperbola into another which includes two arcs of an Ellipse, together with an algebraical quantity. The rectification of the Ellipse has been since improved by Legendre and Ivory.

To obtain the differential of any integral expression, is always practicable; the great difficulty consists in reversing the problem, and finding the integral which corresponds to a given differential equation. Such equation must be rendered complete before the integration is effected. It was hence a question of much importance, to save unavailing efforts, by determining the conditions necessarily required for integration. Euler, as usual, was the first to discover the rule in 1736; but, only three years afterwards, it was without any communication produced by Fontaine and Clairaut. At a later period, Euler extended the conditions of integrability to the higher orders of Differential Equations, which Condorcet demonstrated with equal simplicity and elegance.

The Modern Analysis thus constantly advancing, received a capital extension about the middle of the last century, by what is termed the *Calculus of Partial Differences*, which applies with singular felicity to the solution of the most arduous and recondite physical problems. It would be difficult to communicate any distinct conception of this subtle doctrine to the uninitiated, but the object proposed may be stated generally as, the method of finding the function of several variable quantities, from the relation merely of the Differential Co-efficients contained in their Complete Differential. The first specimen of this sort of Integration was given by Euler in 1734; but D'Alembert expanded the process in his Discourse on the *General Cause of Winds*, which appeared in 1749. It was likewise employed by both these illustrious mathematicians in the rigorous solution of the problem of the vibrating musical string, the position of any point in the harmonic curve depending evidently on the interval of time, as well as on the relation between the absciss and ordinate. But Euler left nothing unfinished. In 1762 he resumed the subject of Partial Differences, and gave a complete explication of its principles, embodying the mode of calculation by an appropriate Algorithm, in a memoir of the Petersburg Acts, entitled, *Investigatio functionum ex data differentialium conditione.* But still further progress was made by him in the third volume of his immortal work on the Differential and Integral Calculus, which came out in 1770. Euler, having then advanced to differential equations of the second order, digested the whole doctrine of Partial Differences into a clear and systematic form. Yet several important additions and improvements have been since contributed to this intricate subject by Lagrange and Laplace, by Nieuport and Trembley.

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[1] Born at Bologna in 1674—appointed professor of Mathematics there in 1698, and astronomer to the Institute of Bologna in 1711. He died in 1739, having produced several excellent works, in which his taste, learning, and science appear conspicuous.

[2] Born about 1690 at Senegaglia in the Roman State, where he died in 1760. His mathematical researches were published in two volumes quarto, at Pesaro, in 1750. He devoted much attention to the remarkable properties of the curves called *Lemniscata.*

The last great accession to the Higher Analysis, and somewhat resembling the method of Partial Differences, is the *Calculus of Variations.* Of this fine theory, the first trace was shown by the rapid genius of Leibnitz, in his mode of differentiating a curve whose equation itself is supposed to undergo the minutest alteration. The controversies of the Bernoullis concerning Isoperimeters and Lines of the Swiftest Descent, augmented greatly the various resources of that kind of Analysis. But Euler, combining their discoveries, produced a new and direct mode of finding such *Maxima* and *Minima*, and compressed the solutions into a systematic form, in a distinct treatise published at Lausanne in 1744. This elaborate performance led the way for the simpler and most elegant and comprehensive doctrine created by the early genius of Lagrange, and invested by him with a commodious notation. Euler, who was far superior to any feeling of jealousy, readily embraced this improvement, and bestowed on it the denomination of the *Calculus of Variations*, of which he explained the principles and application, after the most complete manner, in a tract appended to the third volume of his great work. The distinction between Differentials and Variations is rather subtle, yet may be easily conceived by considering the nature of the Parabola. When an ordinate shifts into a proximate position, both it and the corresponding absciss acquire *Differentials;* but if the Parameter suffer the minutest alteration, the whole trace of the curve will *vary*, and the infinitesimal mutation which the ordinate thence undergoes is termed its *Variation.* The algorithm adopted to denote *Variations* consists of the Greek letters instead of the Roman or Italic, which have been appropriated to the ordinary *Differentials.* The modes of Integration used in both forms are fortunately convertible.

The Integration of Differential Equations has at length, perhaps, nearly attained that degree of perfection of which it is susceptible. A multitude of expedients are devised for effecting the process in particular cases, but no general and direct method has been yet found. To integrate a differential equation of the first order composed of two variable quantities, is the problem originally known by the title of the *Inverse Method of Tangents*, and is commonly solved by the separation of the indeterminate members, which brings it to a question of *Quadratures.* Some equations consist of parts which, though not separately integrable, will yet admit of integration when combined. Others are integrated by the inverse method of factors; but the process by successive approximations may be regarded as in most cases the preferable mode. The skill of the analyst is chiefly displayed in the evolution of series the most converging.

Of the Theory of the Infinitesimal Calculus, various modifications have been offered during the course of the eighteenth century, which help to elucidate the subject by their contrast, and may be regarded as fine speculations, though they should lead to no material improvements in the practice. The notion of flowing quantities, first proposed by Newton, and from which he framed the terms Fluxions and Fluents, appears, on the whole, very clear and satisfactory; nor should the metaphysical objection of introducing ideas of motion into Geometry have much weight. Maclaurin was induced, however, by such cavilling, to devote half a volume to an able but superfluous discussion of this question. As a refinement on the ancient process of Exhaustions, the noted method of Prime and Ultimate Ratios, or of the Relations of Vanishing or Evanescent Quantities, which Newton preferred in the *Principia,* deserves the highest praise for accuracy of conception. It has been justly commended by D'Alembert, who expounded it copiously, and adopted it as the basis of the Higher Calculus. The same doctrine was likewise elucidated by our acute countryman Robins,[1] who did not scruple to seize the occasion of making a coarse attack on the great Euler. Landen,[2] one of those men so frequent in England whose talents surmount their narrow education, produced, in 1758, a new form of the Fluxionary Calculus, under the title of Residual Analysis, which, though framed with little elegance, may be deemed, on the whole, an improvement on the method of ultimate ratios.[3] To confer more consequence on his innovation, he contrived likewise a set of symbols, and applied his algorithm to the solution of different problems. But it never obtained any currency, and soon fell into oblivion.

The method of *Analytical* or *Derivative Functions,* which has since acquired such celebrity, was darkly anticipated by Dr Waring, one of the profoundest but most obscure of algebraical writers. This elegant theory was concisely sketched by Lagrange in 1772, and enlarged thirty years afterwards into a distinct work; the same subject having been treated very fully and somewhat differently by Arbogast in 1800. It is grounded chiefly on the inversion of Taylor's theorem, the co-efficients of the several terms of a Derived or Expanded Function involving the successive orders of its Differentials. But Lagrange deduces the formula from considerations purely analytical, and endeavours thence to erect a science on strict logical principles, entirely disengaged from ideas of Infinitesimals or of Vanishing Ratios. It may however be doubted whether, with all his ingenuity, he has attained that object, or gained, indeed, any real advantage. A mathematician so deeply imbued as that sublime genius with the spirit of calculation, would almost spontaneously regard a process of analysis in the same light as a train of legitimate reasoning. However satisfactory may seem the origin of Derivative Functions, if we examine it closely, we shall probably find the demonstration to rest merely on the strength of analogy, which surely is not the most conclusive sort of argument. But though the method of Derivations should not possess that logical superiority over the Fluxionary or Differential Calculus which its author fondly supposed, yet is the invention entitled to the highest praise for its beautiful perspicuity and its ready and most extensive application. We have only to regret that it has required a new system of characters, when the ordinary notation has become so familiar, and attained so great perfection. Such mutations, like the diversity of languages, may be deemed a serious evil, since they divert the attention to the mere accessaries of learning, and retard or obstruct the acquisition of real knowledge.[1]

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[1] Benjamin Robins, born of Quaker parents at Bath in 1707. He discovered early and powerful talents, which he improved with intense ardour, and soon emancipated himself from the trammels of his cold and narrow sect. Mathematics were his favourite study, but he enriched his mind by a course of extensive reading and the pursuit of general information. He became a successful teacher of those sciences in London, and turned his attention to their practical application. Having cultivated also the art of writing, he distinguished himself by several controversial pieces in science, and even assisted by his pen the opposition to Walpole's administration. He was now so well known as a clever writer as to be employed in correcting Walter's account of Anson's Voyage round the World; but finding the performance very poor, he re-composed the whole. The appearance of this celebrated work in 1748 secured the patronage of the Admiral, and he was appointed Engineer General to the East India Company. He sailed from England at Christmas 1749, and on his arrival in India began immediately the fortifications at Madras; but he fell a sacrifice to that baneful climate on the 29th July 1751. His various mathematical works are stamped with originality of conception, and composed in a clear, neat, and forcible style.

[2] John Landen, born at Peakirk in Northamptonshire in January 1719. Bred up to business, he showed an early talent for Mathematics, which he strenuously cultivated at his leisure hours. In 1762 he was appointed agent to Earl Fitzwilliam, an employment which he held till within two years of his death. Besides his separate publications, he communicated to the Royal Society, at different times, valuable papers on the most difficult parts of mathematical and physical science, all of them distinguished by depth, ingenuity, and powerful invention. It is only to be regretted that, perhaps for want of the collision of society, he indulged a dogmatic and pugnacious temper. He died near his native spot on the 15th of January 1790.

[3] An example will show how Landen's operation might be simplified. Let it be required to find the ratio of the differential of x to that of x^n. Assume v a proximate value or state of the variable x; then by division $\frac{x^n - v^n}{x - v} = x^{n-1} + x^{n-2} v \ldots x^{-1} v^{n-2} + v^{n-1}$, the number of terms being n. But it is evident that the closer x comes to v, the nearer will each of these terms approximate to x^{n-1}. Wherefore, at the coincidence of x with v, the differential of x^n divided by the differential of x is x^{n-1}, and consequently $d\,x^n = x^{n-1}\,d\,x$.

SECTION II.

APPLICATE SCIENCE.

1. DYNAMICS.

This most important science may be considered as grounded on the Composition of Forces. Although the ancients could not fail to remark that the effect of two oblique forces is equivalent to the action of some intermediate force, yet the principle in its simplest form was first distinctly stated, after the revival of letters, by the famous painter Leonardo da Vinci,[2] who being likewise a skilful mechanic and engineer, was acquainted at that early period with the right mode of conducting experimental research. He showed the action of two perpendicular forces against a point to be the same as what is denoted by the diagonal of a rectangle, of which they represent the sides. It would hence be easy to derive the general proposition of oblique forces; but this beautiful property was suffered to remain buried amidst an unpublished chaos of ingenious hints and multifarious projects. Near a century more elapsed, till it was re-discovered in its full extent by Stevinus, a Flemish engineer, who applied it successfully to the explication of the common mechanical powers. About the same time, Galileo, exploring the acceleration of falling bodies, employed the principle of the composition of forces in determining the paths described by Projectiles. Another century nearly passed away before Huygens enriched Dynamics with his elegant theorems of the measure of Centrifugal Force in the case of circular revolutions. But Newton had already, and without receiving any communication, extended Centrifugal Forces to curve lines in general, and had thence deduced the elliptical orbits of the planets. The Dutch philosopher gave a further expansion to Dynamics, by his beautiful theory of the oscillation of pendulums.

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[1] As an introduction to this study, the essay of Robins on *Prime and Ultimate Ratio* may be read with profit. A very clear exposition of the principles will be found in the *Principiorum Calculi Differentialis et Integralis Expositio Elementaria*, a thin quarto published by L'Huillier of Geneva, at Tubingen, in 1795. But the most complete and perspicuous treatise of the Higher Analysis unquestionably is Euler's great work, comprised in seven volumes quarto, printed at different times between the years 1748 and 1797, and consisting of the *Introductio ad Analyses Infinitorum* in two volumes, one volume of the *Calculus Differentialis*, three volumes of the *Calculus Integralis*, to which have been added two posthumous volumes. The treatise composed in Italian in two small quarto volumes, by the late Professor Paoli, though entitled only *Elements of Algebra*, is of a more comprehensive import, and remarkably clear and elegant. The German language has very full and able articles on every part of the Higher Calculus, in Klügel's Mathematical Dictionary. The large French work of Lacroix is valuable for its contents, but deficient in clearness and elegance. His Abridgement seems very obscure and unsatisfactory. The neatest and most concise treatise on the Higher Calculus in the French language is that of Bossut, in two octavo volumes. In English, the Treatise of Fluxions by Simpson may still be studied with profit. Of Maclaurin's large work, the first volume contains an excellent account of the ancient method of Exhaustions, and the second volume is valuable for its physical disquisitions. Our later publications on Fluxions are numerous, but have not acquired such a character as might entitle them to any particular notice.

[2] So called from the name of the place where he was born near Florence in 1452, being the natural son of a notary. Bred in an age and country so transcendant in art, he soon distinguished himself by originality of conception, harmony of design, and elegance of execution. But having likewise ardently cultivated the Mechanical Sciences, he was appointed director of an Academy of Architecture and Engineering by the Duke of Milan, in which capacity he constructed the canal of Mortesana, to supply that city with water. But the political convulsions of that period drove him back to Florence, where he resumed his former profession. Near the close of his days he accepted from Francis I. an invitation to France, where he languished a few months, and expired in the arms of that monarch in 1520. His numerous sketches of projects and machines, with his observations (written backwards), after having been carried to Paris, are now deposited in the Ambrosian Library at Milan, or among the collections at Florence. A digested abstract of these would form a curious monument.

John Bernoulli[1] simplified the science of Equilibrium or Statics, by proposing the principle of *Virtual Velocities*, which Varignon adapted to the several mechanical powers. This consists in the fundamental property, that any system at rest being supposed to suffer a minute derangement, if the velocity of each body, estimated in the same direction, be multiplied into its mass, all those collected products will extinguish each other. Virtual velocities might be therefore viewed as an extension of the principle of the lever.

But the same inventive mathematician afterwards produced another radical property, which he styled the *Conservation of Living Forces*, and which had been suggested by the ingenious hypothesis employed by Huygens for discerning the centre of oscillation. The phrase expressed that permanence, through all the gradual changes of any system of connected bodies, in the aggregate of the products of their masses into the squares of their velocities. This important principle abridges the solution of various dynamical problems, and was embraced by Daniel Bernoulli, the son of its propounder, as the basis of his able and complete theory of Hydrodynamics, published in 1738.[2]

Herman,[3] a disciple and countryman of the Bernoullis, and imbued with the taste of the Leibnitzian school, published, in 1716, under the title of *Phoronomia*, the first regular treatise on Dynamics, drawn up in the analytical or algebraical form. It was clear and compact, but incomplete, and not distinguished by much novelty of conception.

The task of composing a work on Dynamics, full and original in every part, devolved on Euler, who exerted all the resources of his penetrating genius, aided by intense and indefatigable application. This capital performance came out in 1736, in two quarto volumes, entitled *Mechanics, or the Science of Motion*, and exhibited the completest and most elaborate body of analytical investigation that had been yet produced.

James,[4] the elder Bernoulli, in his mode of treating the problem of the Centre of Oscillation, struck out a more direct and ingenious procedure, by which the forces exerted are resolved into separate portions, and an equality obtained between their accelerating and retarding influence. This fine conception, after the lapse of forty years, appears to have prompted D'Alembert[1] to the discovery of the simple and general principle on which he framed his Treatise of Dynamics in 1743. In every system of bodies acting mutually, their several movements at any instant of time may be decomposed into two portions, one which is retained in the next instant, and the other spent; and since an equilibrium must obtain among the lost motions, an expression is hence derived for the motions that are preserved. The most intricate questions in Dynamics were thus reduced to mere statical problems, and solved constantly in the same easy and uniform way. Maclaurin's method of expounding forces by co-ordinates facilitated still further the application of this principle, which D'Alembert in 1744 and 1752 extended likewise to Hydrodynamics, comprehending both the motion and the resistance of fluids.

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[1] John Bernoulli was born at Bâle on the 7th of August 1667, being consequently above twelve years younger than his brother James. He possessed equal genius, but had a keener and more pertinacious temper. Designed by his father to be bred a merchant, inclination led him to the culture of letters, which, from the example and instructions of his brother, he afterwards exchanged for the pursuit of mathematics. The force of his inventive faculty he soon displayed in the resolution of those arduous questions which then agitated the scientific world. The spirit of chivalry had about this period passed over to the learned, and the practice of sending mutual challenges incited application and fomented the talent of discovery. Along with Huygens and Leibnitz, he was the first in solving the problem proposed by his brother, to determine the nature of the Catenarian Curve, or the flexure formed by an equable chain suspended from both ends. Having completed the usual course of education, and turned his thoughts in 1693 to the medical profession, he took a degree in physic. He now travelled into France, and spent some time at the country-seat of the Marquis de l'Hopital, whom he taught the New Calculus. Proceeding next to Holland, he was appointed in 1695 Professor of Medicine and Mathematics (for these sciences were strangely conjoined) in the University of Groningen. The fame he there acquired by his lectures and writings appears to have awakened the jealousy or bigotry of the Calvinistic clergy, who brought a serious charge against him, for impugning the doctrine of the resurrection in a Thesis maintained by one of his scholars, and composed or corrected by himself, which represented the body as in a state of continual mutation, not only the liquid, but even the solid parts being successively absorbed and renewed, and no particle of the composition remaining after a very short term of years. The coolness of the magistrates, however, effectually silenced the ignorant clamour of the Synod, and Bernoulli was pressed to remain in Holland, with flattering offers of promotion. But Bernoulli preferred his native city, whither he was spontaneously invited to succeed his brother. In this honourable station he spent the rest of a long life in extending, by the activity of his genius, every branch of Mathematical and Physical Science. He corresponded with all the foreign societies, and the numerous prizes he bore away proved a source of income. His treatise on seamanship came out in 1714, and his dissertation on the elliptical figure of the planets appeared in 1730. But his various philosophical papers were carefully collected into four quarto volumes, and published in 1742 at Geneva and Lausanne. He died full of years and of glory on the 1st of January 1748.

[2] These two properties—*Virtual Velocities* and *Conservation of Living Forces*—are easily and directly proved from the elementary principle of the composition of forces. See *Elements of Natural Philosophy*, p. 134, 135.

[3] Born at Bâle in 1678. Having been six years Professor of Mathematics at Padua, he accepted an invitation in 1724 to Petersburg; but not long afterwards returning home, he became Professor of Morals and Public Law in his native city, where he died in 1733.

[4] James Bernoulli, the first of a most illustrious race of mathematicians, was born on the 27th December 1654, at Bâle, and educated in the seminary of that frontier city. His father wished him to follow the profession of divinity, but the im-

The slightest incident has often led to the most interesting discoveries. Few would suppose that the spinning of a common top involves the most difficult conditions in Dynamics, and serves to explain all the intricacies of the planetary vertiginous motions. Segner, a celebrated professor of mathematics at Göttingen, and afterwards at Halle, and a man of original and independent mind, published, in 1755, a short dissertation, with the modest title of *Specimen Theoriæ Turbinum*, wherein he showed that every body having a determinate figure, which after combined impulsions is abandoned in free space, will, besides its progressive motion, perform simultaneously, and without the smallest interference, a constant and uniform revolution about each of three principal axes mutually perpendicular, and passing through the centre of gravity. These axes of rotation possess some beautiful but abstruse properties, which the

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pulse of native genius burst through constraint, and hurried him into the ardent pursuit of geometry and astronomy, which he cultivated in private. Alluding to this circumstance, he chose for his device Phäethon driving the chariot of the Sun, with the motto, "*Invito patre sidera verso.*" He began his travels for information in 1676, visited Geneva, traversed France, and eagerly sought the society of men of learning and science. In 1680 he descended to the Netherlands and Holland, passed over to England, and frequented the philosophical meetings in London. After his return home in 1682, he gave a course of mechanical lectures, in which he exhibited the new discoveries. Being appointed Professor of Mathematics in 1687, the fame of his vast attainments drew crowds of strangers to the academy. His genius was a torch of illumination, and the most elegant simplicity distinguished all his profound inventions. In conjunction with his younger brother, he not only found out the secret of the Differential Calculus, on which Leibnitz had given a very short and obscure essay in the Leipsic Acts, but unfolded the principles with such superior talent and address, that the German philosopher had the generosity to regard him as entitled to share in the honour of the great discovery. He pursued the New Calculus with extreme ardour, and applied it most happily to a variety of arduous investigations: He greatly improved the Method of Series, extended the Theory of Curve Lines, approximated to the rectification of the Parabola, and discovered many beautiful properties of cycloids, epicycloids, and spirals. With the logarithmic spiral, which he discovered to renovate itself by evolution, his fancy was so much struck, that, in imitation of Archimedes, but in allusion to the sublime prospect of resurrection, when he should "shuffle off this mortal coil," and rise like Phœnix from her ashes, he directed with a fine enthusiasm this curve to be inscribed on his tomb, with the Ovidian line, "*Eadem mutata resurgo.*"

But such mighty strides required proportional exertion of intellect, and this intense and unremitting application undermined the constitution of Bernoulli, and carried him to a premature grave. He sunk under a slow fever on the 16th August 1705. He had nearly finished his great work on the doctrine of series, and the calculation of annuities and chances, entitled *De Arte Conjectandi*, which was published in 1713. His other miscellaneous productions were not collected till 1744, when they came out in two quarto volumes at Geneva.

[1] Born at Paris 16th November 1717, the fruit of an illicit amour with a lady of high rank, who exposed her infant; but the father, listening to the calls of nature, settled a competent annuity. He was educated by the Jansenists in the *Collége de Quatre Nations*, where he gave early tokens of capacity and genius. After finishing the usual course, he returned to the family of his nurse, with whom he lived forty years in great simplicity, cherishing his independence, and devoting himself wholly to mathematical pursuits and the cultivation of general literature. Such was the progress he made, that he was admitted, at the age of 24, a member of the Academy of Sciences, and two years afterwards he produced his Treatise on Dynamics. The germs of the Calculus of Partial Differences appeared in his Dissertation on Winds, which obtained the prize from the Academy of Berlin in 1746. His new dynamical principle he applied to the investigation of the Earth's vertiginous motion in 1749, and to the theory of the resistance of fluids in 1752. About this time he engaged with Diderot in the compilation of the *Encyclopédie*, wrote the famous introductory discourse, and furnished several capital articles, especially in mathematical science. But he now sought to distinguish himself likewise in philosophy and literature, and published a variety of tracts, which gave occasion to controversy and violent opposition. But this hostility carried his reputation to a higher pitch. He corresponded with the great Frederick of Prussia, but refused the flattering offers of that Monarch and of the Empress Catharine of Russia. The literary honours he enjoyed at home were more agreeable to his taste. Having become secretary to both Academies, he was esteemed the head of the philosophical body at Paris. His works are numerous in various departments. He was a close, accurate, and original thinker; and his style partakes of the same qualities, neat, hard, and precise. He died on the 29th October 1783.

great Euler investigated with that profound talent and luminous method which distinguish all his productions. The curious discovery of Segner drew likewise the attention of D'Alembert and Lagrange, and deserves to be regarded as one of the most important additions ever made to the science of Dynamics. It has contributed signally to the advancement of physical astronomy, and thrown a clear light on the theory of the nutation of the earth's axis, and of the precession of the equinoxes.

Dynamics might seem to have nearly reached its perfection, when Lagrange in 1788, by combining the principle of D'Alembert with that of virtual velocities, converted the whole into an absolute analytical science. His procedure was to refer the efforts of every particle of a moving system to three mutual perpendiculars, and thence derive three several differential equations, which being integrated, would give the final solution of the problem. But to discover a general form of integration is the great difficulty which still remains. All attempts to remove this obstacle have hitherto failed, and we are reluctantly obliged to remain satisfied with merely partial and approximative methods. It must be confessed that the subtilties of the Higher Analysis have been often displayed with very little effect, and that the most celebrated mathematicians, in resolving some arduous questions, especially those involving physical considerations, have still not advanced beyond the vague and imperfect results which sagacity had with very slender aid already attained. Analysts affect too much the air of generalizing, and deceive themselves with expectations which are never destined to be realized. It is thus that Nature appears to set limits to the soaring of human genius.

Statics and Dynamics, though really grounded on observation, depend on principles so simple, and apparently so congruous to reason, that they are often derived from mere abstract considerations, or the consonance of geometrical analogies. But the constituent properties of bodies lie beyond the reach of anticipation, and can be explored only by experiment. Every body may be divided into parts, and each of these parts again subdivided; nor has any limit been yet found to this repeated process of decomposition. Each separate portion likewise retains all the properties of the mass from which it was detached. Hence the corpuscular elements, or the materials that form bodies, have precisely the same character as the compounds themselves. But though imagination represents an interminable series of subdivisions, such cannot be the actual constitution of nature, which is always defined by number and measure. We may therefore infer the existence of certain ultimate portions or atoms, endued with the very fewest qualities, but which by their various combinations constitute the particles of matter, or form the corpuscular composition of bodies.

Every body whatever can have its dimensions contracted or dilated by the application of force; and the extent of this effect is limited only by our circumscribed power. The atoms must hence be held together by some mutual appetite, whose intensity varies with the intermediate distance. This tendency is evidently repulsive within a certain interval, and attractive beyond it. But the essence of matter consists in impenetrability, and therefore the repulsive force must increase from approximation above any finite measure. The inherent power, thus variously changing at near intervals, will merge at remote distances into the great law of attraction.

Such is a brief outline of the reasoning by which the ingenious Boscovich[1] in 1759 supported his beautiful Theory of the Constitution of the Universe. It was partly suggested perhaps by the modification first proposed by Clairaut on the Newtonian System, which assumed the attractive power to be composed of a small portion of the inverse cube of the distance, joined to the ordinary term of the inverse square. But the idea of the Ragusan Philosopher was far more general, exhibiting this power as what algebraists call a *function* of the distance. He rendered the conception still clearer by means of a primordial curve stretching to indefinite distance, of which the ordinates on either side of the axis indicate the corresponding attractive or repulsive force. The extended horizontal branch includes the solar attraction, the alternate convolutions of the curve mark the proximate changes of cohesion, and the final descending branch, by its continual approach to a perpendicular, intimates the insuperable repulsion which prevents the collapse of matter. The intermediate alternations of the curve are unknown; but as in their progress they cross the extended absciss from above or below, they mark the limits of instability or stability. In this way the different constitution of solid, liquid, or gaseous substances may be represented. The atoms being likewise variously grouped, must by their blended action produce that immense diversity of effects which animate the spectacle of the external world.

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[1] Roger Joseph Boscovich, born in the small republic of Ragusa on the 11th of May 1711; received his elementary instruction under the Jesuits, who noticed the promising talents of the youth, and sent him to complete his education in their college at Rome. He soon attained great eminence in erudition and science; and became Professor of Mathematics and Astronomy successively at Rome, Pavia, and Milan. In 1753 he performed the mensuration of a degree in the Papal States, and during the intervals of that laborious occupation he composed in three octavo volumes a treatise of elementary mathematics, remarkable for its simplicity and elegance. He was afterwards employed in several public negotiations, and the claims of his native state brought him to London, where he spent some time, mingling in the societies of the

It is to be regretted that Boscovich obscured his fine theory by an infusion of scholastic metaphysics: He maintained that those atoms or physical points had no magnitude, or differed from mathematical points only in being endued with primary force. But this difficulty, which proceeds rather from our modes of conception than from the actual state of things, might be obviated, by supposing the atoms to have real dimensions, though far smaller than any assigned measure. The primordial curve can likewise be presumed to advance, not by insensible gradations, but by a succession of most minute steps. This slight modification would accord with the tendency of atoms to collect into certain regular groups, a property which seems deducible from the principles of crystallography and the theory of definite proportions. We thus catch a glimpse of the recondite composition of corpuscular elements.

The Boscovichian Theory reduces the investigation of the properties of bodies to the utmost simplicity, and may be regarded as a very happy extension of the great law of attraction. Why it has not been received with more favour, especially on the Continent, might provoke some surprise. Being probably considered as too speculative, it has never been studied with the attention it deserved. Purged of its antiquated metaphysics and crude chemical notions, it would form the best introduction to general physical science.

A portion of that beautiful theory, however, is now, in a modified shape, very commonly received, especially by the continental philosophers, who view the constituent molecules as held together by their mutual attraction opposed to the repulsive energy among the attached particles of heat. It is a supposition which readily explains the general properties of bodies, and serves to elucidate their structure and internal operations.

The Boscovichian System assumed the general principle, that every substance whatever is capable of contraction and dilatation. But this was not admitted at the time in its full extent, the noted experiment of the Florentine Academicians seeming to have established the absolute incompressibility of water. The conclusion however was too hastily drawn; for though the liquid included within a hollow sphere of gold resisted the blows of a hammer, and burst the shell, yet the celerity with which it spirted through the crevice, only displayed the elastic force resulting, as Bellegradi rightly observed, from an expansive effort to recover its previous condition. But the actual condensation of water and other liquids under pressure was first shown

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learned, and composed his *Poem on Eclipses*, which exhibits a neat view of the Newtonian Philosophy. Thence he went with an embassy to Vienna, where he observed the transit of Venus in 1769. On the suppression of the Jesuits by Pope Ganganelli in 1772, he was invited to France, and appointed Director of Optics. But the Parisian philosophers derided his school of theology, and undervalued his scientific talents; and after a residence of ten years, he returned in disgust to Italy, and printed in 1784 his *Opuscula* in five quarto volumes at Bassano. Chagrin and vexation in the decline of life preyed on his sensitive mind; and he sunk by degrees into a deep melancholy, which ended in utter and hopeless insanity. But from this deplorable state he was relieved by death on the 13th of February 1787. Boscovich possessed a fine geometrical taste, joined to considerable powers of invention in a variety of subjects.

experimentally in 1762 by our ingenious countryman Mr Canton,[1] who measured the effect by means of a sort of large open thermometer, containing the fluid in a very capacious glass ball, which terminated in a long capillary tube. Professor Zimmerman of Brunswick in 1779 carried this condensation much farther, having introduced water into the cavity of a brass cannon, and compressed it by a force exceeding the weight of 300 atmospheres. Still the popular and elementary treatises, neglecting such decisive facts, continued to repeat with complacency the paradoxical assertion, that water retains the same volume under every degree of compression. Nor was the public recalled from its careless acquiescence, till the mention of some experiments of enormous compression performed at great depths in the Atlantic Ocean. But the celebrated Oerstedt of Copenhagen has lately made an elegant improvement of Canton's method, by which the condensing power exerted on water by a progressive pressure as high as thirty atmospheres, is most easily and accurately measured. By a further extension of the apparatus, the contractility of various solid substances could likewise be readily ascertained, which might lead to the detection of facts interesting in the economy of Nature.

2. HYDROSTATICS AND PNEUMATICS.

The theory of the Pressure and Equilibrium of Fluids is readily deduced from the principles of Statics, joined to the consideration of the internal mobility of the fluid particles, or their absolute indifference to maintaining figure. But the ordinary demonstration seems incomplete, without taking likewise into view that *Compressibility*, which belongs in a more eminent degree to fluid than even to solid substances. The particles retreat from the action of pressure, contracting on all sides, till the repulsion occasioned by their mutual approach becomes a sufficient countervailing force, diffusible in every direction. Hydrostatics is therefore a complete science. The conditions of equilibrium had been discovered by Archimedes, but Stevinus traced the effects of fluid pressure, which Pascal afterwards explained.

Hydrostatics, or rather Hydrodynamics, which treats of the *Motion of Fluids*, is a subject of far more difficult investigation. Torricelli gave the first traces of this theory, which exercised the sagacity of Newton, and yet required considerable correction. The fundamental problem is to find the discharge of water through a small hole in the bottom of a cylinder filled with the fluid. This efflux amounts only to about five eighth parts of the first emission; and to explain the discrepancy, the immortal author of the *Principia* had recourse to the supposition of a cataract, or funnel-shaped conoid, by which the various streamlets bend their course towards the orifice. But the theory was not investigated in a more rigorous and systematic manner, till half a century afterwards, when Daniel Bernoulli[2] published his important treatise of Hydrodynamics.

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[1] John Canton, one of our most diligent, skilful, and accurate experimental philosophers, was born at Stroud in Gloucestershire in 1718. His father, a broad-cloth weaver, bred him to the same trade; but the youth, incited by the lessons of an elementary teacher, had from his earliest years imbibed a taste for mathematical studies, and continued to devote every leisure moment to those fascinating pursuits. The ingenuity he showed in constructing sun-dials drew the notice of his more intelligent neighbours, who kindly fostered his efforts, and lent him instructive books. Nothing has contributed more in England, not only to spread general information, but to awaken latent genius, than the circulation of popular compendiums and dictionaries of science. With these aids the ardent application of Canton made such rapid and striking progress, that his patrons counselled him to quit the loom and repair to the metropolis, the great mart of talent. In 1738 he was admitted assistant in a mathematical school in Spital Square, and afterwards became partner and successor in the concern, which he conducted during the rest of his life. Without aspiring to the higher walks of science, he was active in the search of knowledge. He devised new experiments, and carefully repeated those in vogue; thus extending our acquaintance with Electricity, Magnetism, and some parts of Physical Chemistry. But his career was short, for he died of a dropsy in 1772.

[2] Daniel, son of John Bernoulli, born at Groningen 9th February 1700, conjoined the hereditary talent with a mild and balanced disposition. He was only five years old when his father returned to Bâle, where he prosecuted his education, and enjoyed the peculiar advantages of paternal aid, and the inciting emulation of his brother Nicholas. Being destined for the profession of physic, he sought to improve his medical attainments by resorting to the schools of Italy. There he published in 1724 his *Exercitationes Mathematicæ*, and already acquired such reputation that he was pressed to become director of an academy projected at Genoa. This offer, however, he declined, but soon afterwards accepted, along with his

The subject was next discussed in 1744 by D'Alembert, and with the depth and originality which distinguish all his productions. This celebrated philosopher, eight years thereafter, advanced to the arduous investigation of the *Resistance of Fluids*, and displayed the resources of his invention, in evolving a variety of ingenious formulæ. Euler likewise, by a series of repeated progressive essays between the years 1755 and 1772, successively simplified the theory of Hydrodynamics, and reduced the doctrine into a strict analytical form, the whole comprised in two differential equations of the second order. Lagrange followed next, and discussed in 1781 the chief difficulties which encumbered the theory; and five years thereafter, he simplified still further the mode of investigation in his *Mécanique Analytique.*

But it is rather mortifying to confess, that these refined speculations are of little avail in the practice of the science. It is indeed impossible, by any effort of analysis, to embrace all the physical conditions concerned in such an intricate system of internal corpuscular motions. Assumptions become necessary for the sake of abbreviation, and the process of integration itself is seldom if ever complete. The results drawn from such laborious researches are, after all this parade of rigid accuracy, to be viewed as only near approximations, which could often be attained by much easier means. It would therefore be preferable in many cases to study the physical relations more closely, avoiding the abuse of abstract calculation, and to rest satisfied with arriving at the conclusions by a sort of balance of errors. In the sober application of analysis, Daniel Bernoulli was singularly happy, guiding his steps always by the light of experiment and observation. And, since the result of the most elaborate investigation is very seldom better than a simple approximation, it seems more judicious in such researches to lay the chief stress on the estimate of physical principles. After the most strenuous efforts of genius displayed during the eighteenth century, the theory of the motions of fluids has really not arrived at more precise conclusions than those first assigned by the penetration of Newton. Nay, so far from reaching any higher degree of perfection, some of the recondite speculations of Lagrange and Poisson, those particularly relating to the extent and celerity of waves, and the general undulatory commotions in fluids, involve consequences which are palpably at variance with the known phænomena of Nature. In such complicated investigations, the safest mode of proceeding is to follow the example of astronomers, who determine the co-efficients of the several analytical formulæ, by the comparison of observations. The simplest and most elementary theory is hence rendered subservient to practical use.

The principles of Hydrostatics constitute the grounds of Naval Architecture, which embraces the theory of the Construction and Sailing of Ships. To this very important branch of science, Euler turned his mighty talents, and produced in 1749 a large and elaborate work, containing a series of ingenious propositions, but which unfortunately are not the best adapted to actual practice. About the same time the celebrated Bouguer,[1] combining geometrical skill with the stores of experimental knowledge, exa-

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brother, a more flattering invitation from Peter the Great of Russia, to hold a prominent station in the Institute then founded in the new capital. Nicholas soon sunk under the severity of that northern climate, but Daniel remained till 1733, when he was appointed to the professorship of physic at Bâle. In quitting Russia, he did not forget to recommend for successor his countryman Euler, who, though seven years younger, had been associated in some degree as his fellow-student. Bernoulli during the rest of his life pursued at home his philosophical investigations with unwearied assiduity and eminent success. He gained or shared most of the prizes given by the different learned bodies over Europe. In 1734 he divided with his father the honour of solving the very difficult problem of the inclination of the orbits of the planets. But his great rival was Euler, nor did their frequent collision ever cool the warmth of mutual friendship. Bernoulli long enjoyed the high respect due to his talents, his virtues, and many amiable qualities. He died on the 17th March 1782.

[1] Peter Bouguer, born on the 10th of February 1698, at Croisic in Lower Brittany, where his father was royal professor of Hydrography, and had shown abilities by publishing an esteemed treatise of Navigation. Under such guidance he imbibed a very early taste for mathematics, and having distinguished himself at the Jesuits' college of Vannes, he was, after a strict public examination, found qualified to succeed his father when only fifteen years old. Notwithstanding his immature age, he discharged the duties of his office with dignity and success. But he found leisure also to pursue his private studies, and in 1727 he gained a prize of the Parisian Academy for a paper on the Masting of Ships, and obtained other prizes in the following years. His Treatise on the *Gradation of Light* appeared in 1729, and established his high reputation. His celebrity always increasing, he was appointed in 1735 to join the famous scientific expedition sent out to

mined the subject in its details, and reduced the theory into a form remarkably simple and elegant. When a body floats on the surface of water, it is held in equilibrium by the action of two equal and opposite perpendicular forces passing through its centre of gravity, and the centre of buoyancy or that of the fluid displaced by immersion. Its weight draws it downwards, while the buoyant effort presses it directly upwards in the line of *support*, the vertical position of those centres being essential to the stability of flotation. The centre of buoyancy does not remain constant, but shifts with the inclination of the natant body. The sustaining force may be conceived to act at any point in its direction, and consequently where the line of support crosses the axis. On this point of concourse, Bouguer bestowed the appropriate name of *Metacentre*, as the limiting position which determines the conditions of flotation, there being stability whenever it stands above the centre of gravity, but the contrary if it falls below. This useful theorem he had invented in 1746; and nine years afterwards was published his investigation of the several motions of ships under the impulse of wind. That inquiry rested too much, however, on the ordinary resistance of fluids, which needs material corrections. It is not very difficult to measure the primary shock of the fluid particles; but, since they accumulate on the front of the body while it advances, the most arduous task is to estimate the force expended, in turning them aside into the general mass, and restoring the diffuse quiescence. To include such multiplied conditions, which are still essential towards a correct and complete solution of the problem, would evidently transcend the powers of the most complex analysis. The utmost that can be effected is only an approximation, which may be easily obtained by adopting a simplified hypothesis, and correcting the terms from observation.

The most complete set of experiments on the resistance of water in narrow canals was made by Bossut between the years 1766 and 1775, and forms the groundwork of his valuable theoretical and practical treatise on Hydrodynamics. It hence appears that water has its celerity reduced to the tenth part, by flowing through a smooth leaden pipe whose length is four thousand times its diameter, or that every particle of the fluid has its motion extinguished and successively renewed ten times during the passage along the extended cavity, by grazing against sides and again relapsing into the current. If in this case, therefore, the whole pressure were distinguished into an hundred equal parts, one of these alone generates the velocity, the remaining ninety-nine parts being expended in merely surmounting the impediments to the flow. A similar consideration was made the basis of Practical Hydrodynamics by Dubuat, who in 1786 gave simple and easy formulæ, for determining the discharge of pipes, canals, and rivers.

Smeaton, our celebrated engineer, performed a series of experiments by means of small models in 1759, on the action of water and wind against the floats or sails of mills. The results obtained on such a narrow scale have, notwithstanding their unavoidable imperfection, been adopted into general practice. Other later observations made by Banks have likewise gained credit among our artisans. The most skilful experiments however of that kind were instituted by Eytelwein of Berlin in 1799. But the recent observations made at Fahlun in Sweden are decidedly the completest and most scientific which have been yet performed.

The usual method of investigating the resistance of Fluids is to estimate the momentary shock or impact of their particles against the anterior surface of the penetrating body. But a more complete and elegant solution may be derived, from considering the pressure caused by

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measure a degree of the meridian under the equator. He spent ten years on the lofty chain of the Andes, prosecuting with unabated ardour a variety of new, ingenious, and important researches. On his return to Europe, he poured forth a flood of most interesting information in most branches of physical science. His last works related to the construction and sailing of ships. Incessant labour and intense application had worn out his constitution, and he expired on the 15th of August 1758. Few persons have contributed so largely to the promotion of Natural Philosophy as Bouguer, who united the rare qualities of an able mathematician and a skilful and accurate experimenter. Like studious persons little conversant with the world, he is alleged, however, to have had the misfortune of a jealous and irritable temper.

the incessant accumulation, and therefore condensation, of the medium in the track of the passage through it. There is likewise another retarding force occasioned by the constant dilatation of the fluid in the rear of the advancing body. In the case of the gaseous media, this impediment often rises to a great amount. When the velocity of penetration, for instance, through common air exceeds 1350 feet each second, a vacuum is formed behind the missile, which thence suffers a retardation equal to the weight of a whole atmosphere. This consequence was first remarked by Robins in the flight of cannon-balls, and it completely deranges the parabolic theory. He was mistaken however in restricting the effect to such extremely swift motions; for the same consideration applies in every degree of rapidity, the condensation and corresponding dilatation of the air close to the anterior and the posterior surfaces of the ball being proportional to the square of its celerity. Hence the measure of retardation is always affected by the shape of the rear, as well as of the front of the projectile.

Robins employed an ingenious method of determining the impulse of balls, by firing them against a heavy loaded pendulum, whose deflection correctly indicated the momentum thus communicated; and by intercepting the flight at different distances, it was easy to discover the loss of velocity, and consequently the resistance opposed by the air. Borda, assuming a much lower scale of velocities, followed a different mode in the valuable set of experiments on the retardation arising from fluids which he performed between the years 1763 and 1769. He particularly noticed the influence of the figure of the hinder part of a moving body in modifying the resistance of the medium. Dr Hutton adopted the Ballistic Pendulum of Robins in his most extensive series of experiments executed with great circumspection on Woolwich Common during the years 1790 and 1791. It comprehends the whole range of velocities, from 5 feet in a second to 2000. The resistance appeared to increase in a ratio faster than the square of the velocity, and therefore Hutton proposed to increase the index 2 by a small variable addition. This modification however is not conformable to the physical principles. Coulomb has shown, by his very delicate *Balance of Torsion*, that, in the case of extremely slow motions, the resistance of fluids is proportional to the velocity simply. The complete expression of resistance therefore includes probably, besides the second power, likewise the first and third, of which the co-efficients are to be found by a scrupulous comparison of the results. More precise experiments are still wanted, to improve the science of Gunnery.

The flow of air through a small orifice suffers nearly the same loss as water, or delivers only about five eighth parts of the measure indicated by theory. But, in passing through long trains of pipes, the several gases appear, from some recent though very limited experiments of Girard, to encounter proportionally still greater obstruction; insomuch that a stream of air would require a pressure exceeding tenfold its emergent force, to enable it to work its way through a pipe whose length is 180 times the diameter.[1] It is a question hitherto overlooked, but of real importance in the economical distribution of pipes for conveying coal or oil gas.

Water and other liquids, when heated, are observed to flow more freely from a very narrow aperture or through a long capillary bore, owing evidently to increased fluidity or the greater internal mobility of their particles. From a very slender syphon pure water near boiling will drop six times faster than on the verge of freezing. But air seems not affected in the same way: If it be forced by a certain pressure through a long capillary tube of glass laid horizontally in a water bath, the current, so far from accelerating, will become retarded by the application of heat. This discrepancy is occasioned by the dilatation of the fluid, which enfeebles the rate of discharge.

The progress of chemistry during the eighteenth century has brought us acquainted with other kinds of air or gases besides the atmospheric. But their mechanical properties are not so easily determined. The very inferior density of hydrogen gas was first discovered in 1766 by Cavendish, who made it ten times lighter than common air. By some late experimenters it has been represented as even sixteen times lighter, when carried to the highest state of purity. This conclusion, however, appears very doubtful, since it involves hypothetical considerations. It is very difficult to detach the latent moisture and to weigh accurately the dried gases contained in large glass balloons. This experiment, though quite practicable, remains still to be performed; and there is reason to suspect that the alleged lightness of hydrogen gas has been much exaggerated. But Pneumatic theory suggests a method of ascertaining the relative density of any gas, which is at once most ready, and susceptible of very considerable accuracy. It is only to observe the time of a given discharge of the fluids, from a small orifice, and under the action of a certain pressure; when the density will, in like circumstances, be inversely as the square of the number of seconds elapsed.[1] But the celerity of the flow may be discovered indirectly by another mode, which is practised with the greatest ease and nicety by any person possessing a fine musical ear. He needs only to send the gas through a detached organ pipe, and distinguish the precise note which it yields, or find another pipe in unison with it; the inverse subduplicate ratio of these lengths will express the relative densities of the fluids. This suggestion deserves to be pursued.

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[1] The general complexion of the fact had been accidentally noticed before at Wilkins' great iron-works in Wales, where the nozzel of the bellows of a blast furnace being inserted into the one end of a train of large pipes, the efflux from the other end scarcely affected the flame of a candle.

When air is thrown by pressure through a small round hole, either into free space or into a close vessel with a wider exit, it must evidently spread in diverging streamlets, and suffer a certain degree of rarefaction. The radiating discharge of a fluid thus involves a principle,[2] which explains a number of curious facts. Water rushing in a foaming current along a pipe or confined channel, leaves a partial vacuity at the sides, from which a small inserted syphon would draw a stagnant liquid to a considerable height. This was particularly noticed in 1795 by Venturi, who termed the property *Lateral Action*. On the same principle depends the suspension and play of a small ball above a jet of air from hydraulic bellows or a condensing engine. Hence likewise an explication of a seeming paradox in the action of fluids, lately considered by the ingenious Hachette. If a pipe bent directly downwards swell below into a cone with an horizontal base, encircled by a narrow rim, and pierced with a central hole, a strong current of air issuing through that aperture, but having a circular plate fitting closely with a weight appended, so far from blowing away the water, will draw it forcibly and support the load. The sheet of air between the opposite surfaces being kept rarefied by its diverging streamlets, the external atmosphere presses strongly upwards. The experiment is reducible to the simplest form; for a common tobacco-pipe held inverted, will by mere blowing be made to suspend a card from its bowl. The safety-valve therefore of a high pressure engine may not always afford the expected protection; under peculiar circumstances it will remain attached at a very small distance, allowing only a partial escape of steam in very thin diverging streamlets.

The like effect is produced in the expanding discharge of water from a narrow circular outlet. Here the streamlets dividing from the centre, draw in air and keep it rarefied by their rapid divergence. The adhesion fails with a rectangular aperture, the streamlets then proceeding in parallel lines. On a modification of the same principle depends an elegant experiment of Ampere. If water be projected horizontally from the bottom of a tall vessel through a vertical slit, this able philosopher observed that the sharp parabolic stream will at a certain distance form a sort of node, and sink into a broad arch. The different retardations of the exterior streamlets appear in this case to determine the change of appearance.

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[1] These methods of experimenting present themselves to a mathematician, but perhaps the first intimation of them was given in the *Experimental Inquiry into the Nature and Propagation of Heat*, p. 534. Since a delicate musical ear can distinguish even the quarter of a note, the error of observation in the second mode should not exceed the 64th part, which seems a nearer approximation than is attainable in any other way.

[2] See the article METEOROLOGY in this Encyclopædia.

Brook Taylor had shown that a musical chord during its vibrations has the swelling outline of a trochoid. But Euler and D'Alembert drew a more general conclusion, and proved that the curve might consist of several intermediate branches, subject merely to certain conditions depending on the *Theory of Partial Differences*. The solution of the problem gave occasion to a controversy between those illustrious philosophers, the former maintaining that the portions of the harmonic curve might be *discrete*, and the latter, in conformity with the great principle of Leibnitz, contending for their necessary *continuity*. But Daniel Bernoulli, avoiding the mazes of intricate analysis and visionary metaphysics, gave a clear investigation based on experiment. He established from induction that a vibrating string naturally divides itself into aliquot parts, which perform independently their several oscillations during each sweep of the whole chord. Applying the same kind of reasoning to wind-instruments, he showed that a cylinder of air which, by its tremor darting in the cavity of a tube with the rapidity of sound, produces its fundamental note, divides, likewise according to the force of intonation, into halves, thirds, fourths, or fifths, which segments yield at the same time their melting subordinate notes. Hence a musical tone is never single, but consists in the union and concord of certain elementary sounds. And such is the origin of Music, which receives its harmonious composition from the balance and concert of Nature. The theory of Rameau, which D'Alembert took the pains to expound, is reducible to the same principle. Those acute subordinate notes rise at times above the fundamental, or outlive it. Hence the shrill expiring note of a deep-sounding bell, and hence also the narrow compass of the French horn, which yields merely the successive natural tones according to the force of the blast.

These natural tones are derived from the mutual relations of the simple series of numbers 2, 3, 4, and 5. The ratio of 1 to 2 is evidently compounded of the ratio of 2 to 3 and that of 3 to 4, and these ratios mark the sweetest concords. The interval between the $\frac{2}{3}$ and $\frac{3}{4}$ is $\frac{8}{9}$, and between $\frac{3}{4}$ and $\frac{4}{5}$ it is $\frac{15}{16}$; which fractions indicate a tone and a semi-tone, the latter differing from unit only by about half the difference of the former. But $\frac{3}{4}$ may be split into $\frac{8}{9}$, $\frac{9}{10}$, and $\frac{15}{16}$; and hence $\frac{8}{9}$ and $\frac{9}{10}$, though not quite equal, are both deemed tones, the former being called the Major and the latter the Minor. The fraction $\frac{2}{3}$ is therefore composed of $\frac{8}{9}$, $\frac{8}{9}$, $\frac{9}{10}$, and $\frac{15}{16}$; and thus seven divisions, consisting of three tones major, two tones minor, and two semi-tones, fill up the whole extent of the fraction $\frac{1}{2}$, which is hence termed the *octave*. It is impossible to express an equal subdivision of ratios by small numbers, but twelve semi-tones may be interpolated with tolerable nearness. Speculative authors have endeavoured to adjust or *temper* the scale, and for this purpose they have sometimes proposed the application of logarithms. Wallis illustrated the Theory of Music with his ingenuity and stores of erudition. In the earlier part of the subsequent century Malcolm and Smith produced learned treatises on the subject. But Euler himself, having at different times resumed the investigation, composed an ample treatise on the General Principles of Music.

It is curious to compare the different degrees of sensibility possessed by the organs of seeing and of hearing. The eye extends its perception over a range of intensity from one to beyond a billion, or from the feeblest glimmer of twilight to the dazzling glare of the meridian sun. But it loses its grasp unless the impression lasts nearly the tenth of a second on the *sensorium*. Hence a momentary gleam of light, as in Electricity, may elude observation, while a brand whirled quickly round appears a continued circle of fire.[1] The discrimination of the human ear has a more limited extent: It comprises only eight octaves, from the gravest to the sharpest note, or from those produced by only 16 vibrations in a second to those excited by a succession of 8192 vibrations in that interval. Such extreme rapidity might seem far beyond the reach of our faculties; but it is the nature of a musical note to repeat its action till another arises; and this divided duration, short as it may be, is sufficient to impress the auditory nerve.

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[1] This remark might serve to elucidate the more recondite Electrical Theory. A variety of curious appearances are explained from the same principle. Hence likewise the ingenious toy lately brought forward and called by Dr Paris the *Thaumatrope*.

The application of the Higher Calculus to unfold the Motions of the Gaseous Fluids has exercised the skill and ingenuity of the greatest analysts, without producing however any material results. But what is really valuable has been obtained, by the simplest theory guiding experimental research. One of the finest corollaries drawn from the principles of Pneumatics is the method of ascertaining the heights of mountains by Barometrical observations. Pascal was the first to propose this nice problem, after the success of the famous experiment performed at his suggestion on the summit of the Puy de Dome. But the essential element of the solution—the relation between the pressure and the density of the air—had not been yet discovered. Twenty years elapsed till Richard Townley, assisting at some of the experiments which Boyle was making to refute the miserable objections of Father Linus, perceived that simple law, which the English philosopher confirmed by other more extended experiments on the compression and dilatation of air. But in 1676, Mariotte, a French experimenter, endued with greater penetration, and possessing some geometrical skill, published a work on the Atmosphere, of high merit for the time, and stamped with originality. He had instituted a clear set of experiments for investigating, and stated the result in explicit terms, that the *Density of the Air is always proportional to its Compression.* From this law he sought to derive the graduated rarefaction in the upper regions of the Atmosphere. He thought the variation of a line by the barometer near the level of the sea should answer to an ascent of $10\frac{1}{2}$ toises, which is the same in English measures as the tenth part of an inch for $75\frac{1}{3}$ feet. He then proceeded to find in succession the thickness of the strata of air corresponding to 4032 twelfth parts of a line in the whole mercurial column of 28 inches. These strata he remarked might be found by Logarithms; but contenting himself with a rough computation, he adopted an arithmetical instead of the geometrical progression. Hence he reckoned the air to be 4032 times attenuated at an elevation of 15 leagues or $43\frac{7}{16}$ miles, which is a tolerable approximation, the true height being only $41\frac{1}{2}$ miles.

Mariotte had therefore no very distinct conception of the great property that at equal ascents in the atmosphere the density of the air diminishes in a continued proportion. This beautiful theorem appears to have been first discovered and demonstrated about the year 1662 by Huygens, who never took the trouble, however, to publish it.[1] But in 1685, Halley gave an elegant geometrical demonstration of the property, founded on the relations of the segments included between the hyperbola and its asymptotes. For the sake of round numbers, he assumed 30 inches for the standard mercurial column, air at the surface having 800 times less density than water; and he made the elevation proportional to the difference of the logarithms of these columns, the interval between 30 and 29 inches corresponding to 900 feet. This rule, drawn directly from theoretical considerations, was found to apply with tolerable accuracy to an observation made a few years afterwards on the top of Snowdon. Newton generalized the problem in his *Principia*, by taking into the estimate the decrease of gravity in receding from the centre of the earth, and arrived at the conclusion, that the densities of the higher strata of the atmosphere form a geometrical progression corresponding to the altitudes disposed in harmonic proportion. But this correction may be deemed superfluous in most cases of barometrical measurement.

It was only wanted, therefore, to rectify the method of Halley, by trying it with observations made at great altitudes. But, for more than half a century afterwards, the subject of barometrical measurement was entirely neglected in England; and, instead of being improved on the Continent, it had relapsed into confusion, and became involved in hypotheses fostered by the lingering influence of the Cartesian philosophy. Bouguer returned to the right path, and availed himself of the opportunity afforded in surveying the stupendous Cordilleras, to compare theory with observations on the grandest scale. His investigation was not published, however, till 1753, when he gave the very simple rule which is the ground of all the modern practice: *That the difference between the logarithms of the barometrical columns, reckoning as integers the first four figures, and deducting a thirtieth part, will express the altitude in* TOISES. To accommodate the result to English measures, it is only required to *add*, instead of *subtracting*, the thirtieth part of the logarithmic difference, to denote *fathoms*. But still there were considerable discrepancies which the ingenious observer endeavoured to remove by some plausible suppositions respecting the elasticity of the air. To find the density of that fugacious fluid, he proposed an experiment which marks originality of conception: It was to note the relaxation of a pendulum or the rate of its diminished sweeps at different elevations in the atmosphere.

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[1] The demonstration, with its date, is given on a Dutch Almanac, now preserved in the Library of the University of Leyden, which, among other valuable notices, contains various microscopical observations, and a judicious parallel between Descartes and Bacon, whom he censures for his ignorance of Geometry, his violent opposition to the Copernican System, and his general inattention to the progress of physical and astronomical science.

The chief cause of the perplexity was owing to the variable influence of heat on the density of the air. No further improvement could therefore be made till that effect had been ascertained, and the difference of temperature between the stations in every case measured by the application of an accurate thermometer. De Luc has the merit of reviving the subject, and of pursuing his researches with ardour, skill, and perseverance. Geneva, his native city, from its position near lofty mountains, afforded the greatest facility for conducting extensive observations. He began his excursions among the Alps in 1754, and soon perceived the necessity of improving the barometer, and rendering it more portable. By carefully boiling the mercury within the tube, he was enabled to expel any particles of air or of moisture which adhered to its sides; and having adjusted the level of the basin, he affixed to the instrument a scale marked with fine subdivisions. But instead of following the decimal division, and distinguishing the inch into a thousand equal parts, he unfortunately took an irregular sequence, by adopting *lines* or twelfth parts, which he broke down again into sixteenths.

The construction of the thermometer engaged his particular attention. He tried alcohol, and various refined oils, and discovered their great defects. He was therefore induced to prefer mercury, which, besides other advantages, he found, by the methods practised by Renaldini and Brook Taylor, to possess the essential property of expanding very nearly equally with equal accessions of heat. Substituting that mineral fluid for the dilute spirit of wine, he merely corrected the divisions of Reaumur, reckoning the arbitrary number of eighty degrees from freezing to boiling water. Corresponding to each of these degrees, he determined the expansion of air by heat to be the 215th part, which answers to a 269th on the centesimal scale.

The rules which Deluc inferred from numerous experiments and observations were published in 1772 in his able but very diffuse work entitled *Recherches sur les Modifications de l'Atmosphere.* Two years afterwards they were reduced to English measures, and simplified by Maskelyne and Horsley; and the problem of barometrical measurement appears then to have excited much attention in our island. General Roy computed and observed the heights of mountains in Wales, and Sir George Shuckburgh at the same time, and for a similar purpose, ascended the lofty summits of the Alps. They had the advantage of employing barometers constructed by the celebrated Ramsden; and their conclusions, published in 1777, accordingly very nearly agreed, making the difference between the logarithms of the mercurial columns to express the elevation in fathoms at a temperature only the fraction of a degree below the freezing point. Since that time little more improvement has been effected, though several circumstances that modify the solution of the problem, especially the influence of humidity, might require to be reconsidered. Laplace indeed has introduced some niceties which appear hardly suited to such imperfect data, and render his formula extremely complex and inelegant. Till the modifications of the atmosphere be measured with much greater precision, we may rest satisfied with a simple and rapid approximation. Nay, the application of logarithms might in most cases be superseded, by employing a very easy proportion.[1]

The mutual appetency of the elemental atoms includes both the *cohesion* of the particles of a body to each other and their *adhesion* to a different substance; and since this cohesive force belongs alike to solids and to fluids, it only preserves their volume, and does not essentially maintain the firmness or figure of a body. Hence the small detached portions of liquids run into globules or drops, and hence also they may be retained in a vessel at some height above the brim. In very narrow glass tubes, water and other liquids will indeed stand considerably higher than the level. This curious fact was first distinctly noticed by Aggiunto, one of the leading members of the *Academy del Cimento*, who died at an early age. But the completest series of experiments on Capillary Action was made by our countryman Hauksbee. He proved that it is not affected by atmospheric pressure, and succeeds equally well in *vacuo;* he showed the ascent of water and other liquids between proximate glass plates, and compared it with the rise in narrow tubes; and he ascertained the elevation to be always inversely as the width of the bore or the separation of the plates. He found the same property belongs to plates of marble and brass, and remarked the ascension of water in an open barometer tube crammed with fine ashes. Dr Brook Taylor likewise performed several ingenious experiments on this subject: Having joined two plates of glass at their vertical sides so as to form a sharp wedge, he dipped it in a sheet of water, and observed the liquid to rise and form a rectangular hyperbola; thus clearly exhibiting the relation of the ascent to the interval between the proximate surfaces. But he pursued the phænomena of corpuscular attraction still farther, and measured the adhesion of a disc of glass to water and mercury. Seventy years afterwards this inquiry was resumed by the celebrated Guyton-Morveau, who endeavoured to ground upon it the chemical theory of Elective Attraction. The attempt however was fallacious, because the force required to detach a disc of glass, marble, or metal, from a surface of water or mercury, is not a single effort, but combines the adhesion of the liquid particles to the solid with their cohesion to each other.

In 1718 Dr Jurin, being led to examine the phænomena of Capillary Action, proposed a theory for their explication which seemed at least plausible. He rightly ascribed the rise of water in the cavity of the tube to the close attraction of the internal surface of the glass, though he did not perceive the way in which that force must act. He fancied the suspension of the slender column of liquid to be caused by the attraction of the ring of glass immediately *above* the summit. But such an assumption was quite illusory, for the ring *below* that limit would evidently exert an equal force in the opposite direction, and thus extinguish the influence of the former. This singular oversight very long however escaped remark, and Jurin's hypothesis became popular and commonly adopted.

Clairaut, discussing the equilibrium of fluids in his famous work on the Figure of the Earth, incidentally examined the property of Capillary Attraction, of which he gave a profound but incomplete analytical investigation. The acute Segner took up the subject in 1754, and gave a different solution, distinguished by its depth, ingenuity, and general accuracy. Assuming as a principle, that the attractive energy is confined to a mere exterior film of the liquid, he found the curve of the upper surface to be what is called the *Lintearia*, or the cavity of an inflated sail formed by an uniform tension. The results he obtained were perfectly accordant with the phænomena, except the figure of a drop, in the determination of which he had, from overlooking the double curvature, committed a small error.

Nearly half a century more elapsed till any further attempt deserving notice was made to improve the Theory of Capillary Action. In 1802, a short dissertation on the subject, drawn up for a particular occasion, and cast into a popular form, was inserted in the *Philosophical Magazine.*[1] It set out from the simplest principles, refuted the notion of Jurin, proved that the attraction of the inner surface of the glass must be exerted *laterally*, and showed from the nature of fluids how such a force would produce a *vertical* effort in the liquid column. The author had designed to expand the outline into a strict analytical investigation, that should embrace the whole range of the phænomena, but deferred the task on account of the more interesting objects which happened then to engage his attention. This unpretending essay, though little appreciated at the time, appears however to have recalled the attention of philosophers to a subject so long neglected. In less than two years the late lamented Dr Thomas Young resumed the investigation of Capillary Action after the manner of Segner, and obtained a very complete solution, but which required, besides, the admission of a repulsive force among the particles of the liquid at a certain small distance. At the mention of Dr Young's name the historian must pause. None of our countrymen has approached more nearly to the character of the celebrated Dr Brook Taylor. Possessing the same ingenuity, extensive learning, varied accomplishments, and profound science, he combined likewise a concise, hard, and sometimes obscure mode of stating his reasonings and calculations. He manifested some chagrin at seeing Laplace, within a twelvemonth after, digress from the train of his *Mécanique Céleste*, to produce an analytical investigation of the phænomena of Capillary Action, so closely resembling his own in the general conclusions. The illustrious French Philosopher, overlooking the previous advances that had been made, and little solicitous about tracing physical principles, trusted to his consummate skill in the process of calculation, and involved the subject in a maze of intricate and abstruse *formulæ*. The reflections drawn from Dr Young on that occasion were extremely judicious, and deserve to be held up to view at present, when such a false taste prevails as threatens to involve the science of our island in specious mysticism. "It must be confessed that, in this country, the cultivation of the higher branches of the Mathematics, and the invention of new methods of calculation, cannot be too much recommended to the generality of those who apply themselves to Natural Philosophy; but it is equally true, on the other hand, that the first mathematicians on the Continent have exerted great ingenuity in involving the plainest truths of mechanics in the intricacies of Algebraical formulas, and in some instances have even lost sight of the real state of an investigation, by attending only to the symbols, which they have employed for expressing its steps." (*Lectures on Natural Philosophy*, vol. II. p. 670.)

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[1] *As the sum of the mercurial columns is to their difference, so is the constant number* 52,000 *to the approximate height.* This number is the more easily remembered from the division of the year into weeks. For a condensed explication of the subject of Barometrical Measurement, see *Elements of Geometry*, 4th edition, p. 454–456.

Laplace's intricate formula for Capillary Action has been since unravelled by the acute discrimination of Mr Ivory, who disjoined it into two separate portions; the one depending on the adhesion of the watery film to the inside of the tube, and the other resulting from half the cohesion of the particles of the liquid to each other. But our ingenious countryman deduced these elements of the complete force from the simplest physical principles, availing himself of the property of equable diffusion of pressure through the mass of a fluid. The same investigation gave the measure and limits of depression observed in mercury and some other liquids. The treatise on the Elevation of Fluids which first appeared in the Supplement to this Encyclopædia[2] was a masterly production, which fulfilled every requisite that could be desired.

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[1] In a memorandum bearing the date of December 1798, the principle is thus briefly stated: "The attraction of water to glass, being directed perpendicular to the surface, produces, in consequence of the laws of fluids, a lateral motion, in the same manner as would the pressure of a vertical column equal to that force." It then goes on to investigate generally the curvature of the surface of the water, and gives the simple formulæ $\frac{1}{25}d$ and $\frac{1}{50}d$, for the ascent of that liquid between glass plates or within the bore of glass tubes, the mutual distance or diameter being denoted in inches by d.

[2] *Supplement to the fourth, fifth, and sixth editions*, vol. IV. p. 309.

3. ELECTRICITY.

ELECTRICITY has, from very small beginnings, risen in the space of little more than half a century to the rank of a Science, superficial indeed, but full of interest and splendour. Without engaging the attention of profound philosophers, it owes its progress chiefly to the ardent application of ingenious experimentalists. In this department Hauksbee,[1] a diligent and skilful operator, made some considerable advances soon after the commencement of the eighteenth century. He marked the circumstances of electrical attraction and repulsion, and observed the production of light by friction both in air and in *vacuo*. But to him succeeded a more fortunate explorer of Nature—Stephen Gray—a pensioner of the Charter House, a man of recluse and peculiar habits, and no great reach of mind, yet allured to the pursuit by curiosity and the gleams of fancy. The apparatus he employed was very humble, suited to his slender means. About the year 1720 he gave a catalogue of bodies, which show electricity on being rubbed by the hand, including most substances, except the metals which he could not excite. But in 1732 he was led by a chain of accidents to discover the *conducting property* inherent in certain bodies, by which they are distinguished from such as may become electrical. The fundamental facts thus elicited were in 1739 arranged perspicuously by Desaguliers, who framed the interchangeable epithets *Conductors* and *Non-electrics*, and *Non-conductors* and *Electrics*, and proposed the term *Insulation* to denote the interrupted communication of electrical virtue. In the meanwhile Dufay,[2] keeper of the King's Garden at Paris, availing himself of these discoveries, advanced in the investigation with a keener and more philosophical spirit. Between the years 1733 and 1739 he detected two opposite kinds of electricity, which he called the *Vitreous* and the *Resinous*, the former being excited by rubbing glass, crystal, and other kindred substances, and the latter by the friction of amber, lac, rosin, &c.; and he gave a clear view of the phænomena of electrical attraction and repulsion, by demonstrating that bodies similarly electrified mutually repel, while those dissimilarly electrified attract each other.

Electricity began about this period to draw general notice, and accordingly more efficient means were employed for the exhibition of its properties. The friction of a glass tube or stick of sealing-wax by the hand was abandoned for the adoption of a large wheel to whirl swiftly a globe or cylinder under the pressure of a cushion. Otto Güericke had used for the same purpose a globe of sulphur, and Hauksbee one of glass; but the advantage of applying a cushion was not immediately perceived. One or more gun-barrels suspended horizontally by silk cords, and having small bundles of linen threads fastened to the nearer ends, formed the prime conductors. Such was the clumsy machine then constructed in Germany, and thence introduced into France and England. The curious found amusement in drawing sparks and firing inflammable substances; and experiments of that sort were ingeniously varied and multiplied. The analogy of Lightning to the Electrical Flash could not fail to be remarked, though their absolute identity was not yet proved. Recourse was now had to electric agency, for the mitigation or cure of certain chronic disorders; and with that view principally were different substances subjected to its immediate influence.

The attempt to electrify water in a phial suspended by a hook from the prime conductor, gave occasion at this time to a discovery which constitutes an epoch in the annals of science. The experiment appears to have been originally performed in Poland, but was repeated in November 1745 by Cuneus and Lallemand at Leyden, and described by Musschenbroeck. It hence acquired the appellation of the Leyden Phial or Jar, and consists of a jar or plate of glass covered or *coated* on both sides, to near the top or edge, by a metallic leaf or other conducting surface, which renders it capable of holding a very high *charge* of accumulated electricity. By this wonderful invention, a power was obtained incomparably greater than any former exhibition of electrical influence. The shock or convulsive agitation accompanying the discharge of a loaded jar through the nervous system, at first inspired terror, and still continues to excite surprise and astonishment. The swiftness of electrical communication thus displayed seemed to exceed the rapidity of thought itself. Nollet,[1] a popular lecturer on Experimental Philosophy at Paris, sent the shock with instantaneous effect through a whole regiment of guards; and Watson,[2] an ingenious physician in London, could discover no interval of time in its transmission by a circuit of about six miles, formed partly by a wire, but mostly by the course of the river Thames.

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[1] Francis Hauksbee. Of this ingenious man, the best experimenter of his time, it is mortifying that so little should be recorded. Neither the date of his birth nor of his death is known; but he flourished between the years 1709 and 1731, and appears to have been Curator to the Royal Society of London.

[2] Born in 1698 at Paris, where he died in 1739. He was son of an officer in the French Guards, and had spent his youth in the military profession, which he quitted for the study of chemistry and botany.

Various attempts were now made to explain the electrical phænomena. The ordinary class of philosophers had so long indulged the belief of ethereal media, that they were easily induced to ascribe the powers of electricity to the agency of such a subtile fluid, which might seem at length revealed to our observation. Dufay showed that the electrical machine draws its supply from the ground, and Watson advanced a step farther, in assuming that every substance naturally holds a certain share of the fluid, which in a charged jar is redundant on the one side and deficient on the other, or distributed in a *positive* and *negative* state. The credit of inventing this Theory has been assigned to the celebrated Franklin,[3] who might probably without communication have hit on the same idea, and is certainly entitled to the merit of expounding it in a clear and interesting manner. The shrewd American, without possessing any superlative talents, or the advantages of education, had, by industry, judgment, and perseverance, raised himself to a conspicuous station in society. Having some tincture of science, and a taste for experiments, he was peculiarly fortunate in choosing a subject of inquiry which so well accorded with the pitch of his acquirements. He had repeatedly visited England, and after his return to America he maintained a constant interchange of letters with his friend Peter Collinson, a wealthy grocer in London, but a zealous botanist, who valued learning, and held a regular and extensive correspondence over Europe. Through this channel of communication, was Franklin early apprized of whatever chanced to engage attention in the scientific world; and his observations were in their turn quickly transmitted across the Atlantic, and conveyed from England to France and Germany. Having carefully studied the important art of writing, he had attained a style remarkably simple and perspicuous, which gave the best effect to all his compositions. His explication of the Leyden Jar, from the redundancy and defect of a single fluid, was favourably received both at home and abroad; though the hypothesis of a vitreous and a resinous fluid, proposed by Dufay, and generally preferred on the Continent, appeared to explain the principal facts with equal readiness and facility.

But it was reserved for the American philosopher to complete a grander discovery, which, though unreasonably extolled, is the foundation of his permanent fame. The similarity of Electricity and Lightning already struck several experimenters; and the Abbé Nollet had in 1746 drawn a parallel, in which he compared the conglomeration of thunder-clouds to the prime conductor of an electrical machine. Winkler next, and with more decided arguments, contended for the identity of those powers. Franklin, following the same train of speculation, enumerated in a clear and methodical order the different circumstances of resemblance. But it was necessary to pass the circle of mere probabilities, and he proposed as the final proof to have recourse to direct observation. His suggestion was, to erect on the top of some eminence a tapering iron rod 40 feet high, which he conceived would attract electricity from the charged thunder-clouds. Preparations were accordingly made in France for trying that bold experiment. In the spring of 1752, Dalibard, a distinguished botanist, had an iron rod 40 feet in height tied with silk cords to a post in the neighbourhood of Paris, the lower end being protected from rain by a sort of sentry-box. The apparatus was, during his absence, intrusted to the charge of a resolute carpenter, who watching the first appearance of a thunder-storm on the 10th of May, ran to the spot, drew sparks from the rod, and, assisted by the curate of the village, actually charged an electric jar. The demonstration of the nature of Lightning was thus rendered complete; but an experiment so wonderful deserved repetition. It was eagerly performed, under the direction of Buffon, in the Royal Garden at Paris; and, during the months of July and August, it was tried with the same results near London, where Canton succeeded in detecting atmospheric electricity by means of a common fishing-rod.

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[1] John Anthony Nollet, born at Pimpré, in the district of Noyon, on the 19th of November 1700. From that obscure retreat he was drawn by his growing reputation; and his amiable character secured the support and encouragement of zealous friends. He had the advantage of visiting England and Italy, and those journeys procured him the favour of the King of Sardinia, and afterwards the patronage of the Royal Family of France. Enjoying some appointments at Paris, he for many years gave regular courses of Natural Philosophy, and by his popular and eloquent lectures, and his skill in preparing and exhibiting the illustrative experiments, he spread a general taste for science. His elementary works, without aiming at originality, are remarkably neat and clear. He died much regretted on the 24th of April 1770.

[2] William Watson, born in London in 1715. Bred an apothecary; and being very prosperous, he turned physician. He was active and ingenious, with some talents, and still greater pretensions. By his ardour he extended considerably the knowledge of Electricity. He died in 1787, having the year before obtained the honour of knighthood.

[3] Benjamin Franklin, born at Boston in 1706, and died at Philadelphia on the 17th of April 1790. His political career is well known, and his literary progress has been sufficiently appreciated.

Intelligence now came from America, that Franklin had performed his experiment in a finer style. Not having the opportunity of an eminence in the flat country around Philadelphia, he imagined the expedient of employing a boy's kite, to gain a great elevation in the air. To the end of the hempen string, from which hung a small key, he fastened a piece of silk cord, for holding in his hand. On the 15th of June in the afternoon, while a storm was gathering, he walked into the fields, and, assisted by his son, he launched the kite, when, to his inexpressible delight, he saw the loose fibres stretch out from the string, heard a snapping noise, and observed the pendant key not only to attract light substances, but to give sparks on approaching his knuckle. These were all decisive marks of electrical action, and answered his most sanguine expectations. The success of this trial encouraged him to entertain the daring project of turning aside the stroke of heaven, and of guarding our edifices from the ravages of thunder, by the erection of lofty conductors. These views, combined with amusing experiments and lively speculations, were explained at great length, and in a very easy and pleasing manner, in the series of letters to Collinson, and through his friendship printed at London in 1755, and immediately translated into the French language, and circulated with zeal and rapidity over Europe.[1]

Notwithstanding the enthusiasm excited by the dispersion of that work, the scheme of annexing conductors to buildings was yet slowly adopted. The first one erected was by Watson, at his villa near London, in 1762; two years afterwards, they appeared in Germany; and not till the year 1776 were they applied to protect some cathedrals in Bavaria and Italy. They have spread since in all directions, especially on the Continent, flowing, it might seem, with the tide of Franklin's political celebrity.

But his famed hypothesis, if examined strictly, will be found to rest merely on the extension of vague analogical considerations. If a pointed wire sensibly draw electricity at the distance of a foot from the prime conductor, through what a wide range, it is argued, must a long tapering rod shoot its influence in the vast magazine of the atmosphere! It may be shown, however, that the point acts only on the electrified air which streams from the machine, and by repelling again laterally those affluent particles, facilitates their continued flow. The slightest impediment to the motion of the aërial currents reduces the action of the point; while, on the contrary, a knob or blunt termination may acquire the same influence as a pointed end, if the flow of electrified air towards it be maintained, either by rendering the ball very hot, or by sticking to it a small lighted taper. The idea of *stealing* the lightning from the thunder-cloud, and silently disarming the fulminating agent, is therefore utterly chimerical. To produce such an effect, the whole body of succumbent air must discharge its electric store, by actually coming in successive contact with the end of the rod. And, in what reasonable length of time could that extended communication be accomplished? But it is equally futile to suppose, that the terminating of the rod by a point could have the slightest influence, in *tempting* or leading the thunder-stroke towards any particular spot. Yet such was the main argument used in the famous dispute which once agitated the scientific world, with regard to the comparative advantages of terminating the conductors with points or with knobs.

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[1] It deserves to be noted, that the Royal Society, which rarely extends its patronage to untried merit, had refused these ingenious letters a place in their Transactions.

But though any attempt to avert the course of thunder seem preposterous, it is of extreme importance to consider whether the intervention of a proper conductor may not mitigate, or even render innocuous, the fulminating stroke. The coruscation of lightning resembles most the electric spark, its tortuous path being marked by the violent divulsion of the aërial track. The rapidity of transit might indeed be regarded as instantaneous; but Helvig has lately endeavoured, in Germany, to measure it by help of the *Camera Lucida*, and estimates it, from probable conjecture, at 8 or 10 miles in a second, or above 40 times swifter than sound. According to the ingenious Gay-Lussac, lightning often darts at once more than three miles in a rectilineal path.

The ordinary classing of conductors into perfect or imperfect, is very loose and unsatisfactory. Their true distinction consists in the time they require, however short this may be, for the transmission of electrical energy. From a set of peculiar experiments, it would appear that the copper transmits this virtue more than a thousand times quicker than water, which again conveys it several thousand times faster than dry stone. But all the particles of the conductor are thrown during the passage into a state of vehement repulsion, and, consequently, the disruptive effect must be proportioned to the interval of action. A copper tube, or ribband, of even moderate dimensions, if well spread over the roof and continued into the ground, may hence be sufficient to protect a house from thunder, by reducing exceedingly the duration of the repulsive efforts. Iron, which is generally employed, conducts twenty times slower than copper; and lead is still worse adapted for the purpose, since it conducts about a hundred times slower. The electrical energy being conveyed chiefly along the surface of bodies, sheet-copper should decidedly be preferred for the substance of a conductor.[1]

Thunder-rods of the ordinary construction have been now tried seventy years, and the accidents from lightning seem just as numerous and indiscriminate as before. The public is gradually losing its confidence, therefore, in the efficacy of those vaunted protectors; but, in spite of such warnings, philosophers are most unwilling to descend from their proud eminence. When any sinister event occurs, they are solicitous to find excuses and parry objections. They recommend the conductors to be planted nearer, carried higher, and perhaps armed with a cluster of points. It may require a few more of such fatal accidents as the late explosion, in France, of a protected powder-magazine, to demolish finally the Franklinian hypothesis.

But the injury caused by the stroke of lightning is, in this climate, much less considerable, after all, than has been generally believed. The loss of human life by thunder-storms over Europe appears not to exceed annually, perhaps, one individual in three millions. The damage to property from such appalling discharges is likewise comparatively small. The ravages inflicted on the Continent by showers of hail are of a more formidable kind. Those frozen masses are often large, and fall with such terrible force as in the space of a few hours to tear in pieces the vines and batter down the fields of corn over wide and fertile districts. It was an object therefore of still greater moment to mitigate, if possible, the fury of such rageful storms.

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[1] On this important subject see a paper on Electrical Points and Conductors, in the first number of Professor Jameson's *Philosophical Journal*, published in 1823.

About the year 1776, several speculative experimenters, conceiving electricity promoted congelation, and therefore the conversion of the drops of rain into solid icicles, proposed erecting thunder-rods to prevent the formation of hail. It was even suggested, in aid of those protectors, to kindle fires on the high grounds, and to shake the atmosphere by the discharge of mortars. But Heinich showed the futility of all such expedients, in a dissertation printed in the Bavarian Transactions for 1785; and, except the notice of a curious experiment by Seiferheld in 1790, the question seems to have sunk into oblivion. The attention of the public, however, was again for a moment recalled in 1800, by the offer of a prize from the Physical Society at Berlin; but the successful candidates, Wrede and Weiss, proved that hailstones had no connexion with Electricity, and that the various expedients tried for averting them were entirely fallacious. The subject seemed deservedly forgotten for twenty years, but has been lately revived again by the periodical folly of mankind. La Postolle, apparently a zealous visionary, proposed in France with the utmost confidence, as a complete safeguard against the ravages of hail, the erection of a tall wooden pole with straw ropes hanging loosely from the top of it to the ground. He was followed in 1823 by Thollard, another projector equally sanguine. But as the world is governed by names, the powerful talisman or lofty thatched pole received the sounding, though not very classical, appellation of *Paragrèle* or *Paragrandino.* Certificates of its efficacy flowed in from all parts; the storm-clouds were seen by veracious witnesses collecting over those poles, and rolling their hailstones harmless along the straw to the ground. The cultivators of the mountain districts on the confines of France, Switzerland, Italy, and Germany, seemed enchanted by the discovery, and whole fields were planted with those *Paragrèles*, which, like embattled spears, dared the front of heaven. The question relative to the utility of *Hail-Protectors* was now referred to the Institute of France; but that learned body, though it clung to the charm of the Thunder-Rod or *Paratonnerre*, rejected with scorn the pretensions of the *Paragrèle.* But the faith of the believers was not so easily shaken, and a succession of angry and querulous pamphlets for a while kept up the dispute. Yet we may infer that the confidence in the efficacy of such notable protectors is fast declining, since an old auxiliary—the agitation of the air by the firing of mortars—has been recalled to their aid.[1]

In the latter part of the eighteenth century, Electricity was enriched by a continual accession of curious facts and experiments. New instruments were devised, of nicer construction, to measure the intensity of electrical attractions and repulsions. The catalogue of electrics themselves was not only extended, but rendered more definite, by distinguishing the opposite qualities of the substances rubbed. Some steps have likewise been made towards a more precise theory. If a ball electrified vitreously be approached to an insulated cylinder, the nearer end will assume the resinous electricity, while the remoter extremity will indicate the vitreous; the limit of neutrality always advancing to the approximating ball. This capital experiment appears to furnish the true explication of the Leyden Jar. But it involves a more extensive principle: Pressure may be considered as only close apposition, and friction is evidently a case of repeated pressure. Hence the action of the Electrical Machine itself, and hence likewise the theory of that beautiful contrivance, the *Electrophorus*, first announced by Wilke of Stockholm in 1762, but named and fully described in 1776 by Volta[2] of Como, to whom electrical science was afterwards so much indebted for its extension. The *Vindicating Electricity* of Beccaria and the *Returning Stroke* of Lord Mahon depend on the same property. Of a like nature is the accumulation of Electricity by the *Doubler* and other instruments of that sort.

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[1] Orioli, professor of Natural Philosophy at Bologna, seems not disposed to acquiesce in the decision of the Academy of Sciences at Paris. He appeals to the liberality and opulence of the French nation, and gravely recommends it to plant *paragrèles*, armed with metallic wires about 40 feet high, and not more than 500 feet apart, over its wide territory; and farther proposes that the experiment should be continued for ten years, under the inspection of some competent agricultural board. If the sum of 100,000 livres has been raised at his suggestion for that project in the small province of Bologna, what might not be expected from the munificence of such a kingdom as France?

[2] Alexander Volta, descended of an ancient family in the north of Italy, and born in 1745. He embraced the clerical profession; but, devoting himself to the pursuits of natural science, he was appointed to the chair of physics at Pavia in 1774. Electricity engaged his attention, and the observations of Galvani opened to him that brilliant career of discovery

It appears that the electrical state of bodies suffers a modification from every change of their chemical or mechanical constitution. Such alterations are detected by delicate Electrometers, of which the best perhaps may be the gold-leaf one proposed by Bennet in 1787. The origin of atmospheric Electricity is finely illustrated by that sensible instrument, which shows an evolution or an absorption during the condensation of vapour or the transition of water into steam. Hence a cloud suddenly collected from the conglobating vapours is vitreously charged, and flashes its lightnings, which, by the succussion of the air in their devious lengthened tracks, conveyed to our ears with the tardiness of sound, occasion the prolonged rolling noise of thunder.

The power of benumbing the touch, which belongs to a certain fish of the ray kind, thence called the *Torpedo*, and very frequent in the Mediterranean, had been remarked from the earliest times. This singular property was now suspected to be owing to electrical influence; and the zeal of Walsh in 1773 converted the conjecture into demonstration, showing by satisfactory experiments that the animal could send its shock only through conducting substances. But the power of stunning its prey is possessed in a much higher degree by a large species of eel, the *Silurus Electricus*, which was originally brought from Surinam, and abounds in the pools and sluggish streams of the hot region of Venezuela. From a healthy specimen exhibited in London, vivid sparks were drawn in a darkened room. But from a rapid emission of shocks, these animals suffer great prostration of strength; and the celebrated Humboldt gives an amusing account of the method of catching them in New Spain, by driving into the waters where they resort, a number of horses, which, though stunned by the multiplied succussions, yet generally recover and withstand those attacks, till the eels themselves become quite exhausted, and are dragged out helpless. It appears from dissection, that the *Silurus Electricus* is furnished with a very peculiar and complex nervous apparatus, which has been fancifully compared to an electrical battery. But we are entitled only to infer, that the animal is endued with a faculty of modifying, by sudden compression or otherwise, its internal constitution, and consequently its electrical condition.

Electrical agency, by effecting new combinations among substances, has contributed essentially to the advancement of Chemistry. Cavendish discovered the composition of nitric acid in 1788, by passing successive sparks through a mixture composed of certain portions of the oxygenous and azotic gases. By a similar process, he found atmospheric air to consist of the same elements, only combined in a different proportion. But his fine discovery of the composition of water was afterwards confirmed, by concentrating the effort of electrical repulsion, in the experiment that Dr Pearson, assisted by Cuthbertson, an expert electrician, performed in 1799, which evolved those gaseous components. This satisfactory experiment has been since greatly simplified, by one of those happy miniature contrivances, in which the late very ingenious Dr Wollaston so much excelled.

Electricity can be transmitted through the several gases; and the light which it then extricates is brighter in proportion to the condensed state of the medium. As the air becomes rarer, the projected spark assumes a spreading lambent appearance, through all the gradations of colour, from white to yellow, orange, and purple, vanishing into the faintest violet. The most copious display of purperine gleams appears when the air is rarefied about 1000 times, which corresponds to an altitude of thirty-five miles in the atmosphere. Such may be the proper region of the diffuse and tremulous coruscations of the

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which will render his name immortal. Volta was particularly distinguished by the liberal and discerning patronage of Napoleon. During the fervour of reform and revolution, he laid aside the ecclesiastical habits, and married; but, in the decline of life, the early impressions regained their ascendancy, and compunction for the breach of the vow of celibacy preyed on his spirits, and undermined his health. He died on the 6th of March 1826.

Aurora Borealis, which is decidedly an electrical phænomenon. If the rarefaction be pushed farther, the luminous appearance grows always fainter, till it becomes extinct. Accordingly, Morgan[1] found by a very careful experiment that an electrical charge is not conducted through a Torricellian *vacuum,*—an important discovery, since it shows that Electricity, like Heat, can exist only in a state of combination with its recipient substances.

The close of the eighteenth century was distinguished by the accession of a new branch of Electrical Science, more brilliant and astonishing than even the parent stock. It originated in a fortunate incident which occurred in the year 1790. Galvani, whose name it bears, professor of anatomy at Bologna, remarked, in the course of his demonstrations, that the limbs of a dissected frog were strongly convulsed at every spark which one of his pupils happened to draw from the prime conductor of an electrical machine standing in the immediate vicinity.[2] Being thus led to consider the subject, he made several curious experiments, and published a Dissertation on Animal Electricity, which engaged very general attention. The femoral muscles of a frog, bared of their integuments, but left connected with the trunk of nerves, were found to serve as a most delicate sort of electrometer. With this aid, it was easy to trace the faintest vestiges of electrical influence, and to contrast the properties of various conductors. The very weakest chemical solutions, the mere contact of different metals, nay the apposition of animal fibres, were all found in their several degrees to develope electricity. But the simplest mode of exciting it is, by the mutual application of small plates or discs of copper and zinc. Dr Robison made a capital improvement, in proposing a pillar of those discs, like a rouleau of half-crowns, to augment by their combination the intensity of effect. This happy idea seems to have been overlooked, when Volta in 1800 invented his famous *Pile;* the most energetic instrument of all electrico-chemical analysis, and commencing deservedly a new epoch in physical science. By Crookshanks it was rendered far more commodious, in being converted into the Galvanic Trough; which, again enlarged into Batteries sometimes of enormous extent or dimensions, has conducted Davy, Berzelius, and others, to the most splendid and wonderful discoveries.

The Voltaic Pile is only a modification of the Electrical Battery; but its peculiar action may assume two distinct features. It either exerts the slowness and duration of repulsive force, or displays the most intense concentration of that power. Hence the opposite effects produced by very large single plates, and by a very numerous series of small ones. Light and heat are most copiously projected from their recipients by the former, while chemical decomposition is effected with the greatest energy by the latter. But it would require much patient and profound investigation, to discover the working of such recondite principles.

The original design of this discourse was to come no lower than the early part of the present century, and to avoid discussing the merits of contemporaries. But I cannot resist the pleasure of noticing the signal advance which Electricity has lately made. Its close connexion, if not perfect identity, with Magnetism had been long suspected, and was even adopted by several ingenious theorists. This affinity found a most zealous supporter in Ritter; but the fancy and mysticism blended with his opinions had begun before the year 1818 to weaken their influence. In this state of uncertainty, Professor Oerstedt of Copenhagen, happening, in the course of his lectures during the winter of 1819–20, to show his pupils the intense heat excited in a small wire of platinum, laid horizontally and nearly in the direction from east to west, to join the conductors from the copper and zinc plates of a Galvanic Battery, thought of placing under it a small compass, and the needle was observed instantly to turn aside as if it had been drawn by another magnet. This surprising fact was not much heeded by him at the time; but having afterwards carefully traced the conditions of the experiment, he published near the close of the year 1820 his great discovery, which awakened the public attention, and gave rise to numerous speculations that frolic in the giddy maze of electric and magnetic currents.

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[1] A very ingenious person, who died young, being nephew to Dr Price, and brother of the able Actuary of the Equitable Assurance Company.

[2] The Germans lay claim to the origin of Galvanism. Sulze, about the middle of the eighteenth century, had, in his work on Taste, noticed the singular impression made on the tongue by the contact of two distinct metals. But Zimmerman has lately produced a passage from the *Biblia Naturæ,* a book published at Leipsic in 1752 by Swammerdam, in which the author mentions his having observed the convulsions of the muscle of a frog held against a glass tube by a silver wire pendant from a ring of brass. Such facts are curious, and deserve attention; but every honourable mind must pity or scorn that invidious spirit with which some unhappy jackals hunt after imperfect and neglected anticipations, with a view of detracting from the merit of full discovery.

It must indeed be confessed, that after all the progress which Electricity and its younger branch Galvanism have made, the hypotheses commonly received are exceedingly vague and unphilosophical. In cultivating these attractive sciences, experimenters would seem to satisfy themselves with the exercise of a looser and humbler species of reasoning. It is rather amusing to observe the complacency with which some ingenious persons describe the play and vagaries of an Electrical Current, whose existence was never proved. We are acquainted only with electric attraction and repulsion, and with the transmission of electric influence: All beyond these elementary principles, rests on hasty conjecture. Instead of adopting one or two fluids, it were safer to suspend the assumption of any. We can perceive no distinctive marks of the operation of a fluid, which is often confounded with the mere luminous track occasioned by the particles of Light disengaged from the substance of the conductor; the colour of emission being modified by the peculiar character and intensity of the retaining force.

The Theories proposed by Æpinus and Cavendish are entitled, however, to the praise of great ingenuity, and may serve to connect with elegance the chain of principal facts. The latter most accurate philosopher likewise stated the immense disproportion in the celerity of different conductors, though he did not explain the grounds of his conclusions. Coulomb agreed with him in limiting electrical diffusion to the surface of bodies; and the Balance of Torsion showed the intensity of attractive and repulsive power to be inversely as the square of the distance. These were real discoveries, deduced from nice and cautious observation; but his countryman Poisson has since exercised profound skill in the play of analysis, by attempts to explore the hypothetical influence of Electricity, without having arrived, however, at any conclusion that is not obvious or of no value.[1]

4. MAGNETISM.

NEARLY allied to Electricity is the science of Magnetism. The property of attracting iron possessed by a certain stone or metallic ore, was known from the remotest times; but the *directive power*, or disposition to turn always towards the north, that most wonderful property which guides the modern navigator over the dark and desert expanse of ocean, lay hid through a long succession of ages. This remarkable substance derived its name among the Greeks from *Magnesia*, a district of Macedonia, where it was chiefly found.

The Magnetic Compass, with the art of distillation, which was never practised by the ancient Greeks or Romans, seems to have been discovered in Upper Asia, and thence communicated by their Tartarian conquerors to the Chinese. From them again, the knowledge of the invention spread gradually over the East. The Crusaders, during the occupation of their bloody conquests in those regions, had leisure to admire the arts acquired by their more civilized rivals. Having their curiosity thus awakened, they appear, about the latter part of the twelfth century, to have imported into Europe the *Compass*, along with the substance which, mistaking it for *Natron*, they called *Salt Petre*, and of which they had learned the deflagrating property. That invaluable instrument was at first very rudely formed, consisting merely of a piece of the native mineral fixed to a broad cork, and set to float in a dish of water. An artist of the opulent town of Amalphi, the great emporium of the East, and seated on the shore of Calabria, in the direct route of the Crusaders, improved the construction, and marked the north point by a *Fleur-de-Lis*, the armorial bearing of the kingdom of Naples. From its directive property, it was now called in English the *Loadstone* or *Leading Stone*. About a century afterwards, the method of communicating magnetism by the touch was probably discovered, the needle or small bar of steel so treated being then applied to a card suspended on a pivot. The Germans bisected successively the eight cardinal divisions, which had satisfied the Romans and the Chinese, into sixteen and thirty-two points, to which they gave those compound names which are still retained. About this period, when observations were not very precise, the needle was judged to turn nearly towards the north; but Columbus, in his first voyage of discovery, found it to decline from the meridian as he advanced on the Atlantic; and this apparent change of the laws of nature occurred under circumstances which would have appalled a less determined commander. The variation of the compass, however, was distinctly noted in the year 1500 by Cabot, another celebrated Italian navigator.

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[1] Such abuse of a noble science would have merited the censure of the *Dunciad:*

Or set on *Analytic* ground to prance,
Show all his paces, not a step advance.

Magnetism made little further progress, till Dr Gilbert, the founder of experimental science in England, explored the subject by a course of patient and skilful investigation. To this eminent philosopher we are indebted for the discovery of the few connecting principles. Every magnet, whether natural or artificial, has its powers concentrated in two opposite points, termed the north and south poles; and the similar poles of separate magnets repel each other, while their dissimilar poles exert a mutual attraction. When a piece of soft iron is approximated to a magnet, it becomes itself a magnet, the nearest end assuming an opposite polarity, and therefore being constantly attracted. If a long iron bar be held in a position nearly vertical, its lower extremity is always found to manifest the properties of a north pole; and, from this induced power, Gilbert legitimately inferred the magnetism of our globe. He likewise imitated its structure, by fashioning a magnet into a small sphere or *terrella*, and hence illustrated the *declination* of the needle, as well as its *dip*, or the position which it takes when, after being poised freely on its centre of gravity, it receives the magnetic virtue,—a property which had been first noticed by his countryman Robert Norman in 1576. But something more was required to explain completely the directive property of the needle. If a magnetized sewing needle be set to swim on the surface of water or quicksilver, it will not advance towards the north, but readily traverse in that direction. In fact, while the one end is attracted, the other is equally repelled, by the vast magnetic power of the earth concentrated below the Arctic Region, but having really the same quality as what was first named the South Pole of the needle. Those antagonist forces will have no influence therefore to draw it forwards; but if it be turned aside, they will combine their oblique action to bring it back into its meridional position.

Gilbert's original work was republished at Ferrara in 1629, with a commentary by Cabæus, a Jesuit; and fourteen years afterwards another member of that learned fraternity, Kircher, a man of singular talent and immense erudition, produced at Cologne a full treatise on Magnetism, which contained little, however, of sound doctrine, but abundance of fanciful speculation.

Hooke remarked the debilitating effect of heat on the power of the magnet. Newton appears to have sometimes amused himself with magnetical experiments, but did not bestow much thought on the subject: He was disposed to consider the force exerted as reciprocally proportional to the cube of the distance.

The celebrated Halley, who, by his ingenuity, learning, zeal, and enterprise, contributed so largely to the promotion of physical science, now turned his attention to the subject of terrestrial magnetism. In 1683, and more distinctly in 1692, he endeavoured to explain the declination of the needle and its variations, by supposing the Earth to be a hollow sphere with two opposite magnetic poles, but having another solid sphere, of analogous polarity, which revolved slowly within it. From this bold hypothesis, of two fixed, combined with two movable poles, he sought to calculate the changes of internal constitution that are continually going forward. At a time when the method of finding the longitude at sea was extremely imperfect, he proposed the variation of the compass observed in different latitudes, as an easy way of obtaining at least an approximation to that important problem. With this view it was necessary to collect numerous observations made at remote points on the ocean; and in 1699 Halley obtained the command of two small sloops of war, with the rank of post-captain, the better to insure subordination among the crews. Thus equipped and empowered, he traversed the vast Atlantic, diligently exploring both hemispheres, till he was arrested by the icy barriers. On his return in the following year, enriched with a store of various information, he published his Magnetical Chart, in which the limits corresponding on the surface of the globe to every five degrees of declination, were marked by certain curve lines formed by connecting the points of observation. This was the model of all the charts of a similar nature which have been since constructed. One of the most noted was produced by Mountain and Dodson in 1744, and again improved in 1756.[1] Wilke laid down another in 1772, and Lambert sketched out a third in 1776. But the most accurate and complete magnetic chart that has yet appeared, was published by Churchman in 1794. The value of such delineations, however, is unfortunately diminished by the errors proceeding from the local attraction of the magnetic needle, which were quite overlooked at that period.

Between the years 1712 and 1725, numerous experiments were made by Hauksbee, Brook Taylor, and Musschenbroeck, to determine the relation of the intensity of magnetic force to the distance of its action; but though the power appeared to decrease most rapidly with its remoteness, no satisfactory conclusion was obtained. The cause of this failure must be imputed to the intermixing, in the statement of the results, no fewer than four distinct forces, emanating from the several poles. Taylor, the most acute of those observers, reckoned the magnetic force, if exerted very near, to be inversely as the square, but when more remote, as the cube, of the distance. It was reserved for Coulomb,[2] sixty years afterwards, to discover the true law of magnetic attraction and repulsion, by means of his delicate Balance of Torsion, though the same deduction had been previously announced by the ingenious Lambert. The earlier experimenters had sought to ascertain those forces by the loads required to effect a separation, or to counterbalance their action. Graham proposed the more precise method of computing the magnetic forces, from the number of vibrations performed in a given time by the needle; but his suggestion was overlooked, to be invented again, and generally adopted.

The properties of the magnet appear mysterious, though reducible to a few primary facts. But to discover the great pervading principle, still baffles the ingenuity and penetration of the most ardent research. The supposition of a subtile permeating fluid is very generally embraced, though it rather darkens than elucidates the subject. Yet it seemed to receive countenance, from the curve lines marked out by iron-filings when strewed on a sheet of paper or a plate of glass laid over one or more magnetic bars. On a hasty glance, these traces might be regarded as indicating the circulation of an invisible fluid. Euler, whose strength lay in the command of analysis, went so far as to imagine that the pores of the magnet were furnished with a sort of valves, which permitted the entrance of the current and prevented its return. But this amusing experiment is most easily and satisfactorily explained, from the composition of the attractive or repulsive forces centred in the magnetic poles. The curves delineated by the filamentous chains, when two dissimilar poles are exerted, resemble elliptical arcs, but seem hyperbolic ones, if two similar poles unite their action. The magnetic curve is distinguished by some remarkable properties, and one of the most beautiful may be cited: It is, that if from the same points in the axis, tangents be drawn to them, the several points of contact will range in the circumference of a circle.[1]

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[1] These laborious compilers in 1757 gave a table of no fewer than 50,000 observations arranged corresponding to the years 1700, 1710, 1720, 1730, 1744, and 1756. They found it impossible, however, to reduce all the changes to calculation.

[2] Charles Augustin Coulomb, a most accurate and ingenious experimenter, was born at Angoulême in 1736, and died at Paris on the 23d of August 1806. Receiving his education in that capital, he embraced the military profession, and was sent as engineer to the island of Martinique. He afterwards held various employments, and might have risen to the highest distinction, if he had been as compliant with the times as some others of his countrymen.

Æpinus adopted the hypothesis of an active fluid, to explain the phænomena both of Magnetism and Electricity, and endeavoured to reduce its operations to great simplicity. Brugman and others have entertained similar notions. But admitting the ingenuity of such conceptions, they enable us merely to shift the difficulties. We must imagine the constitution of the unknown fluid, while the properties of the magnet itself are obvious to the senses. Sound logic, therefore, dissuades us from indulging in dreams hardly more instructive than the occult qualities of the Schoolmen. The true business of the philosopher, though not flattering to his vanity, is merely to ascertain, arrange, and condense the leading facts.

Ingenuity and patience were for many years exercised in improving the art of constructing artificial loadstones, or of communicating magnetism by different modes of Touch. The general procedure depends on the magnetic power induced by apposition, though it is often affected by very slight circumstances, and always requires dextrous manipulation to insure success. In France, Reaumur and Duhamel gave circumstantial directions; but our countrymen Knight, Mitchell, and Canton, acquired peculiar address in magnetizing; and Æpinus gave an improved method, suggested by his theory, for communicating magnetism by the Double Touch, the two rubbing bars being held each reclining about half a right angle from the vertical position.

It was proved that the magnetic virtue resides near the surface, and therefore hollow magnets were proposed, though perhaps never actually tried. But thin bars seemed to answer best for attaching under the card of the mariner's compass. Coulomb remarked that a steel wire is, by twisting, made capable of being nine times more strongly magnetized. It is singular that cast steel is unfit for a magnet, and that the smallest admixture of antimony destroys the polarity of iron. In the years 1786 and 1787, Cavallo tried the magnetism of various substances, by setting them to float on a very clean surface of mercury, on which they turned nimbly by the smallest force. In this way, he found that a trace of iron which no chemical test could detect was yet capable of sensibly affecting the needle. Nickel is strongly magnetical, but seems enfeebled by the addition of cobalt. Yet brass, though naturally passive, becomes susceptible of magnetism by hammering, and loses this power again when heated to near redness. But a more numerous and far more precise collection of experiments of that kind was made during the course of twenty years, between 1784 and 1804, by Coulomb. This most acute and accurate experimenter found every substance almost to be susceptible of magnetism. To examine the property, he formed needles about three-eighths of an inch in length, suspended by fine silk lines; and these obeyed the magnet, though composed of gold, silver, copper, lead, and tin, nay of bone and chalk. But this seeming universal diffusion of the property might still be owing to the presence of iron, however much attenuated. When bees-wax had incorporated with it a portion of iron-filings equal only to the 130,000th part of its weight, it was yet sensibly affected by the magnet. Nor is it improbable that nickel, as once believed, may be only a refractory ore of iron, still resisting chemical decomposition, though deriving from this source its magnetic virtue.

The variation of the needle has been accurately observed in Europe during nearly two centuries. It seems to be continually increasing, though in a most irregular manner. In the year 1657, it stood directly north at London; and it held the same meridional position in 1660 at Paris. But during the remainder of the century it changed towards the west, at the rate of 11′ annually at London, but only 6′ at Paris. From 1700 to 1725 the yearly increase of variation at London was only 9′, from 1725 to 1750 it rose to 14′; but from 1750 to 1775 it returned to 9′ again, and from 1775 to 1800 it declined to 6′. For the next 25 years the rate of augmentation has been scarcely 2′, and the change at Paris is still smaller. This rapid decline of the annual change appeared to intimate the needle's approach to the limit of westerly digression, from which it would slowly return in the contrary direction. Such expectation, however, is not yet realized. In 1817 the needle was observed at Paris to make indeed a slight retreat; but, in the following year, it moved forward again, and continues to advance, though slowly, to the west. Its relaxation in London is less apparent.[1]

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[1] See *Analysis of Curve Lines*, near the end of the volume.

But the variation of the needle, besides its annual progress, is liable to other alternating changes, amounting sometimes to a considerable quantity. Its diurnal deviation was first remarked by Graham in 1722, and ascertained with more precision in 1750 by Wargentin of Stockholm. But Canton investigated the subject with great ability and perseverance, in a very extended series of observations begun in 1756. He found the needle to travel westwards from about nine o'clock in the morning till two in the afternoon, when it remained for a while stationary, and again slowly returned, regaining its station during the night, or before the early dawn. In the morning, its movements were less regular. The extent of those digressions was found to depend on the season of the year; near the end of December, the diurnal aberration was only 7′, but it mounted to 13½′ about the middle of June.

Canton, with great probability, referred these curious facts to the influence of heat on the magnetic forces. Though the direction of the needle is mainly determined by the internal magnetism of the globe, it must also be affected in some degree by the local attraction of the ferruginous particles united to mineral substances, and profusely scattered on the surface. If we suppose their joint power inclines to the east of the magnetic meridian, it will evidently act more feebly in drawing the needle aside during the warm portion of the day, and in the height of summer. This ingenious explication seems to be corroborated by the observations made in 1794, on the island of Sumatra, by Macdonald, who found the diurnal aberration there not to exceed 3′. But the alternation of heat and cold in that equatorial climate is likewise more limited.

The Dip of the Needle is much less changeable than its Declination. It is more difficult to observe, but appears to have been diminishing during the last hundred years, at the very slow rate of a minute annually. The quantity of Dip, or the depression of a poised needle below the horizontal position, depends in every place over the surface of the earth nearly on the latitude. It would be very desirable to render the observations with the Dipping Needle more certain and delicate. Coulomb proposed an ingenious mode of computation, from the load requisite to bring it into an horizontal position compared with the time of its vibrating in that plane.

Albert Euler, son of the great analyst, censured Halley's magnetical hypothesis, and proposed in 1766 a simple theory deduced from observations, and requiring the assumption of only two poles, distinct however from those of the terrestrial axis. The North Pole he would place in the latitude of 75° 7′, and the South Pole in the latitude of 60° 37′; assigning to the former a western longitude of 91° 54′, and to the latter only 38° 36′.

Biot and Humboldt, from a comparison of later and ampler observations, assigned for both the magnetic poles the opposite latitudes of 79° 1′; the longitude of the northern one being 27° 37′, and that of the southern one 205° 12′ west from Greenwich. The plane perpendicular to the magnetic axis intersects the equator at an angle of 10° 59′, and in west longitudes 117° 37′ and 300° 27′.

But deductions of this kind are liable to a source of inaccuracy which had long escaped observation. The bolts and other pieces of iron in the frame of a ship, ranging mostly before the binacle, very sensibly derange the bearings of the compass by their local attraction. This deviation seems to have been first remarked by

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[1] The celebrated astronomer Burckhardt, by combining together a number of observations, has deduced a formula for the variation of the needle at Paris. Admitting its accuracy, the maximum will be attained in 1837, and reach to 24° 26′, the period of magnetical revolution being completed in the space of 860 years.

Bayly, who accompanied Captain Cook as astronomer in the two last voyages of that great navigator. But it was accurately investigated by Lieutenant Flinders in 1795. The error thus caused is often as much as 10 degrees; and, owing to the oblique influence of terrestrial magnetism, it attains to a much greater amount in the high latitudes. When the vessel's keel lies in the magnetic meridian, the needle is not disturbed, and the divergence becomes greater in the transverse position; in every other position, the sine of the deflexion has a certain ratio to the sine of the angle of the course. A single experiment will determine that ratio, and hence the rectification is easily applied. But Barlow has proposed a very simple contrivance, to avoid the trouble of computation: It is to fix, on the deck and immediately behind the binacle, a thin iron plate, which by its proximity may counteract the diffuse attraction along the forepart of the ship. This adjustment being once attained, must suit every situation.

But the action of terrestrial magnetism is evidently the result of its intensity combined with its direction. Though the attractive force augments in approaching to the magnetic pole, yet the Dip of the Needle rapidly increases, insomuch that the late Arctic voyagers found it in Baffin's Bay only three degrees from the vertical position. The efficacy of the directive force was hence reduced about nineteen times, and the compass betrayed a deviation amounting to 70° or 80°.

The study of Magnetism, so long neglected, has lately been revived with splendid success. Conjoined with observations of the length of the pendulum in different latitudes, experiments have been likewise made on the oscillation of the needle, which indicates the directive power of the great internal magnet. From a comparison of these, it appears that the intensity of the terrestrial magnetism is doubled in the ascent from the equator to the western limit of Baffin's Bay. No person has shown such ardour in pursuing the investigation of this subject as Professor Hansteen of Christiania, who not only with infinite labour collected and digested the multifarious facts, but has undertaken distant journeys for the purpose of rectifying former observations. From all these combinations, he was enabled to detect the position of the magnetic poles of the Earth, and trace the curves of variation on its surface. But the results undergo correction as often as fresh data are procured. Hansteen infers, from experiments he made between the years 1819 and 1826 on the oscillation of the needle, that the magnetic intensity has been decreasing annually at Christiania, London, and Paris, by the 235th, the 725th, and the 1020th parts respectively. This diversified effect he ascribes to the revolution of the Siberian pole.

The remarkable discovery of Oerstedt has greatly enlarged the field of magnetic influence. A wire of any kind of metal being laid horizontally and at right angles to the magnetic meridian, to connect the opposite conductors of a Galvanic Battery, a needle either below or above it is drawn considerably to the one side or the other. Instead of bewildering the imagination with the vagaries of invisible streams, a sufficient explication of the phænomenon may be deduced from two leading principles:—1. Magnetism is in some proportion diffused through all metallic substances, owing either to their peculiar constitution or the universal dissemination of ferruginous molecules: 2. The cross wire, from its position with regard to the Terrestrial Magnet, acquires induced magnetism, but extending transversely; the under side having the virtue of a north pole, and the upper side that of a south pole. The copious infusion of that virtue is occasioned probably by the duration of the internal tremor, excited by intense electrical action, and analogous to the effects on a bar of iron or steel subjected to hammering, twisting, heating, or the fulminating shock. Hence are easily explained the diversified phases of attraction, rotation, or impressed magnetism.

Arago proved that continuous electrical sparks or discharges operate the same combinations as the Galvanic Battery. But his penetrating ingenuity soon discovered the means of augmenting prodigiously the intensity of the magnetic action, by coiling the conjugate wire into a cylindrical spiral, and thus forming a sort of magazine of transverse inferior and superior needles which unite their influence. Schwegger, pursuing the same ideas in Germany, has produced a very simple and convenient instrument, for detecting the smallest traces of magnetic virtue.

Magnetism has again received a beautiful accession from the keen glance of Arago, whose mind embraces and enriches every department of science. If a needle be finely suspended over a thick circular plate of copper made to revolve horizontally, it is drawn aside from the meridian in the direction of the motion; and when this becomes very rapid, it will even follow the tide of circumvolution. The effect is nowise occasioned by the whirlwind raised, for the experiment succeeds best when the needle, pendant from a silk line, is inclosed within a glass case that has a bottom of mica or thin glass resting immediately over the plate of copper. The power is augmented by the proximity of the needle and the thickness of the revolving disc,—an evident proof of the attraction exerted by the accumulated ferruginous molecules.

The simplest and most satisfactory way of explaining this curious phænomenon seems derived from the principle, that, though magnetism acts instantaneously, a certain portion of time, however small, is required for the infusion or communication of the magnetic virtue. The circular plate acquires this property from the mere apposition of the needle; its axis with reversed poles lying when at rest exactly under the pointer. But if the plate be quickly turned, the axis, not being instantly impressed, will be carried forward, and must consequently draw after it the needle, or even involve it in a continued rotation. On the other hand, if the copper remain fixed while the needle is made to vibrate, the axis of induced magnetism must always hang in the rear, and therefore retard, or tend to diminish, and soon extinguish the oscillations. Hence an important practical inference, that the needle of a ship's compass should traverse near the bottom of a thick copper box, in order to correct that excessive sensibility which is so inconvenient in ordinary seamanship.

Magnetism has been gaining accessions likewise in detail. Seebeck of Berlin proved that various substances have their magnetical state affected by the unequal distribution of heat. Becquerel described an instrument which, by neutralizing the terrestrial influence, shows the faintest shades of magnetism, and distinguishes the slowest electrical conductors. His countryman Rousseau, advancing by the same path, gave the construction of the *Sideroscope*, which detects the very feeblest traces of iron in bodies. This curious combination of magnetic needles has been improved and successfully applied by Leballif, who devotes the moments of respite from the drudgery of a laborious office to the ardent and unwearied pursuit of experimental science.

5. OPTICS.

THE science of Optics, next to that of Astronomy, is the noblest creation of human genius. No branch of knowledge so far transcends ordinary notions, and none has more essentially contributed to augment our perceptive powers or expand the range of observation. The sense of Touch, diffused with various intensity over the surface of the body, connects us with the proximate objects of an external world. Taste is akin to Touch, and makes us acquainted with those solvent properties of food which stimulate the animal frame. The sense of Smell is not confined to mere contiguity, but extends its information to the substances which emit from a distance their peculiar odorous effluvia. Hearing carries our sensations still farther, and intimates the operation and the direction of those distant changes which excite the tremulous commotion of sound in our atmosphere. But the faculty of Vision is of a much higher order. It soars above the grossness of matter, transports us above this sublunary scene, and holds commerce with the skies. The other senses have gained no help from instruments, if we except the partial advantages which Hearing has derived from the speaking and ear trumpets. But Sight was refreshed by the application of Spectacles, and its powers of exploration have been advanced in a most astonishing degree by the tardy subsequent discovery of the Microscope and the Telescope. The wonders of atomic Nature seem now laid open, and all the glories of the remotest celestial forms are brought under immediate observation. The medium of such intercourse is that pure empyreal stream of Light, which approaches the nearest to our conception of Spiritual Essence.

The chief properties of the rays of Light consist in *Reflexion* and *Refraction*. With the former the ancients were sufficiently acquainted, but they had only a vague notion of the connexion between the angles of Incidence and Refraction. It is somewhat singular that both the Telescope and the Microscope should have been several years invented before the law on which their construction depends, or the constant relation between the sines of those angles, was detected. This important discovery was made by Snellius, but simplified and first published in 1637 by Descartes, who greatly reformed optical science. The progressive motion of Light was next beautifully deduced from the annual anticipation and retardation of the eclipses of Jupiter's satellites, by the ingenuity of Röcmer, a young Danish astronomer, who had been invited to France in 1672, and there liberally entertained for nine years, till he was recalled to his native country and loaded with lucrative and honourable appointments. One might suppose that the *aberration* of the fixed stars, or their apparent circular shifting in the heavens, would have been hence anticipated, as a simple inference from the motion of Light combined with the revolution of the Earth in its orbit. Such a consequence had been foreseen by the acute mind of Descartes, who therefore adopted the *instantaneous* propulsion of light as a fundamental principle in his Dioptrics. Were it otherwise, he maintained the stars would not appear in their true positions, and the sun would be seen eclipsed long after his conjunction with the moon. These considerations, however, were quite overlooked, when Bradley in 1729 established his fine discovery within close limits, but on the very same grounds.[1]

Astronomers had been obliged to abandon their attempts to construct telescopes of much higher magnifying powers, and to contract the apertures, and consequently to reduce the measure of illumination in order to procure distinct vision. Colour was still imagined to depend merely on the various mixture of light and shade. But Newton's grand discovery of the decomposition of the Solar Beam, first communicated to the Royal Society in 1671, and further explained by his correspondence during the three following years, changed the whole aspect of the science. The ingenuity in devising the simple and beautiful experiments with combined prisms, is not more admirable, than the force and clearness of the reasoning which deduced from them such splendid conclusions. The mild spirit of the philosopher was wounded by the attacks of petulance and contradiction; and he quietly retained, in his closet, for the space of upwards of thirty years, the sequel of those invaluable experiments, and only consented to publish the Treatise of Optics after his reputation had finally triumphed over all opposition. This resolution is much to be regretted, as it not only postponed the diffusion of genuine science, but gave occasion to the blending of some speculations which the discerning author would probably not have published in the high meridian of his intellect. Though the experimental procedure on which the work rests had been strictly inductive, yet was the composition cast in a synthetical form,—broken into a series of propositions, with their preliminary apparatus of Axioms and Definitions; which commonly involve assumptions, and so far from giving more precision to our reasonings, imperceptibly lead to the admission of errors. The very term *Refrangibility*, which Newton, under the guise of a definition, applied to the rays of light, became afterwards a source of misconception. It evidently converted the refraction of light into a general property belonging peculiarly to the rays themselves, and therefore independent altogether of the quality or nature of the refracting medium. This might appear only a slight distinction, but it probably contributed to the hasty and inaccurate experimental inference, that in every case the refraction of the mean ray by a prism determines the corresponding refractions of the extreme rays, or that the solar spectrum is always distinguished into the same proportions of coloured spaces. Since all material action, however, is reciprocal, the refractive process cannot be referred to the single agency of the particles of Light, but must result from their mutual attraction to the substance of the transparent medium. It is not the lot of humanity to reach perfection, and the most gifted of mortals will at times betray the weakness of our nature. The subdivision of white light into *seven* component rays, and the distinction of the spectrum into coloured spaces adapted exactly to the intervals in the *diatonic scale* of music, were no doubt fine illusions which reflected the mysticism of the age. But it must now be admitted that the primary colours melt into each other by imperceptible shades, and that the *spectra* painted by different prisms differ widely in their relative extent, and exhibit even a diversified partition of spaces.

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[1] In a letter of Descartes, bearing the date of 1634, he notices an experiment proposed by a Dutch correspondent, to prove that Light takes a sensible time to arrive at the eye from a distance. This was to wave a flaming torch at night, and observe its reflexion from a mirror removed only a quarter of a league. The French philosopher with his friends repeated the experiment several times, and could not discern the smallest interval between each bending of the flame and its reflexion. But even admitting the lapse of the 24th part of an arterial pulse to intervene during the short passage to the mirror and back again, or allowing the velocity of 46 English miles in a second, it would completely derange Astronomical Observations. The sun would not appear in his real position, but in that which he occupied when the rays of light which reach us began their journey. A solar eclipse would therefore be seen, not at the moment of conjunction, but an hour afterwards, the Light having to travel from the Earth to the edge of the Moon and back again, or to pass and repass the distance of 50 semidiameters, each of 3000 leagues.

Certain it is that the philosophers on the Continent generally refused to admit the accuracy of the conclusions of the Treatise of Optics, and Mariotte, the most ingenious and skilful of the French experimentalists, was unsuccessful in his attempts at the prismatic decomposition of the sun's rays. His failure must no doubt be attributed to the influence of prejudice, and the stiffness of advanced age; but finally to silence all such opposition, it was judged expedient in 1716 that Desaguliers should repeat and somewhat vary the original experiments before a committee of the Royal Society at London.

Notwithstanding these few blemishes, arising merely from hasty generalization, the Newtonian Theory of Light and Colours is undoubtedly one of the noblest efforts of human invention. It quickly modified the projects of opticians. The imperfection of the Telescope was hence found to proceed only from undue mixture of colour in the image, occasioned by unequal refraction, which no change in the forms of the glasses could remedy. The Reflexion of Light alone offered any chance of improvement. Newton had constructed a small Catoptrical Instrument with his own hands; but for many years afterwards no artist appeared that possessed sufficient skill to imitate and improve it. The ingenious Mr Hadley in 1723 was the first who succeeded in getting a Reflecting Telescope made for his private use; and we may presume that the great inventor himself, before the close of life, enjoyed the satisfaction of seeing his early ideas realized. Such was not the fortune of James Gregory, whose Reflector, more complex indeed, but likewise more commodious, had remained a mere speculation, till about this time it was manufactured and came to acquire high reputation. James Short particularly distinguished himself by the finished execution of those instruments, and for a long time he maintained the superiority of the English artists. Every improvement in the construction of the telescope contributed to the accuracy of astronomical observations.

Hadley not only gave an impulse to practical astronomy, but soon enriched its stores by that invaluable instrument the Quadrant of Reflexion, which has ultimately produced a complete revolution in the art of observing. A similar instrument was proposed by Newton as far back as the year 1669, in consequence of an unsuccessful attempt of Hooke; but the description had been laid aside and neglected till 1731, when the announcement of Hadley's invention recalled it from oblivion. The mode of finding an altitude hitherto practised at sea was liable to much uncertainty, since it required to direct the eye first to the horizon and next to the disc of the sun, though the instrument might have its position altered during this interval by the motion of the ship. The difficulty was now obviated by employing a movable index, which brought the sun's image to touch the boundary of the horizon. It is a very happy application of the simple principle in Catoptrics, namely, that a ray of light which has suffered two reflexions deviates from its course by an angle just double of the mutual inclination of the mirrors. The Quadrant was afterwards enlarged into a Sextant, it had telescopic sights affixed to it, and received its final simplification in this country from the dividing engine of Ramsden. This delicate instrument has come since into almost universal use in measuring angles; and though originally contrived only to observe the latitude at sea, it is now employed with the greatest facility in ascertaining the angular distance of the moon from the sun or a star, and thence supplying correct data for computing by the help of improved lunar tables the longitude itself.

Meanwhile the Sextant underwent a radical transformation on the Continent, being changed into an entire Circle. This was effected by the celebrated Mayer, whose very narrow circumstances drew forth all the resources of his invention. He sought to remedy the imperfection of the common Graphometer or Circumferentor, by multiplying the angle observed, and thus blending and extenuating the errors of subdivision. By this simple contrivance not only were the grosser inaccuracies obviated, but the instrument was rendered even superior to others of the finest construction. Mayer next conjoined this principle with that of Hadley, and produced the *Repeating Circle*, which, having afterwards received some further improvements from Borda, is now employed universally on the Continent in Goniometrical Surveys, and in the practice of Navigation and Astronomy. This instrument being complex, however, in its construction, and tedious and operose in its application, seems after many trials not to be gaining ground in England. Its chief advantage consists in reducing the errors occasioned by imperfect workmanship, which a more skilful execution might nearly preclude.

The middle of the eighteenth century was distinguished by a capital correction of the Newtonian principle of the proportional refraction of the several rays of light, which has led to the most important practical results. It had been concluded that no combined unequal refractions could ever form a white image, because the same refractive powers which might neutralize the colours must likewise bend the converging or diverging rays into exactly parallel directions. But, dissatisfied with this theory, Euler in 1747 endeavoured to prove the possibility of destroying the coloured margin of a focal image, by imitating the structure of the eye, which he considered as a perfect optical instrument. He proposed to construct a convex lens, by joining two meniscus glasses holding water in their cavity; and expected from such a combination not only to correct the spherical aberration, but to prevent the border of colour. All his attempts, however, to obtain distinct vision, were unsuccessful. Yet he still persisted in holding it to be a Law of Nature, that not the refractions of the extreme rays, but the indices of their powers, are constantly proportional; and from this mathematical or metaphysical assumption, he strictly deduced his calculations. These speculations of Euler made some noise in the scientific world, and shook the confidence abroad in the accuracy of Newton's experimental conclusions. About this time John Dolland,[1] bred a silk-weaver, the trade of his father, a French Protestant refugee, being fond of mathematical studies, had chosen to embrace, in partnership with his son, the profession of an Optician, as more congenial to his taste. Having already acquired reputation for ingenuity and skill, he communicated in 1752, to the Royal Society of London, a short paper, showing that the principle advanced by Euler was discordant with the property deducible from the Newtonian experiments. But it did not thence follow that either of these must be the true Law of Nature; and accordingly Klingenstierna, an ingenious and learned Swedish philosopher, proved that the hypothesis espoused by Dolland would not stand a rigorous analytical investigation. The English artist was therefore compelled to adopt the only sure and decisive mode of settling the question, the unbiassed appeal to experiment. He soon found that his preconceptions were inaccurate, and that refraction may subsist without any fringe of colour. He formed a wedge or hollow prism with two thin rectangular pieces of plate-glass, joined at the edges and cemented to planes of brass at the ends, and having filled the cavity with distilled water, he inverted in it an acute-angled glass prism, and looking through this compound medium, he gradually widened the angle of the glass plates, till an object placed in front appeared free from any coloured border, but considerably depressed. The refraction of the water had therefore predominated over the opposite refraction of the glass, without expanding at the same time the prismatic colours. This simple and well-devised experiment established therefore, in contradiction to Newton, the important principle, that the length of the spectrum, or the *dispersion* of the extreme rays, is not always proportional to the mean refraction, but depends on the constitution of the diaphanous medium. The result already indicated an improved construction of the telescope, by substituting a compound object-glass, inclosing water, nearly in the manner attempted by Euler. But Dolland rejected this imperfect expedient, and sought to produce an unalterable combination with different kinds of glass: Having struck into the right path, he pushed forward to a great discovery. He tried to select among the different kinds of glass such as might effect his purpose; and after a long and perplexing research, he finally preferred the combination of crown and flint glass; the refractive power of the former being to that of the latter as two to three, while their opposite dispersions are equal. A convex lens of crown glass of the focal length of two feet, conjoined with a concave lens of flint glass having a virtual focus at the distance of three feet, must hence form a colourless image at the distance of six feet. This capital discovery, achieved in 1757, enabled Dolland to construct refracting telescopes of much larger aperture and wider field than before, and presenting the image with such a pure brilliancy as to entitle them to the name of *Achromatic.* It was likewise possible to correct the spherical aberration by modifying the coalescent curvatures. But the discharge of extraneous colour is attained most completely by forming a triple object-glass, composed of a concave lens of flint glass inclosed on both sides by two convex lenses of crown glass.

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[1] John Dolland, born in Spitalfields in June 1706. Left by the early death of his father in straitened circumstances, he was obliged to toil for the support of the family. But his thirst after useful knowledge led him to devote every spare moment to private study, and even to encroach on the hours of repose. By such severe application he made considerable proficiency in geometry and algebra, in optics and astronomy, and added to these attainments a tolerable acquaintance with the ancient languages. He became anxious to follow a profession better fitted to his genius, and in 1752 he joined his son Peter, who having quitted silk-weaving, had successfully commenced the business of optician. The discovery of achromatic glasses in 1758 established his reputation, and afforded a prospect of the large fortune afterwards reaped by the industry and perseverance of his successor. But the elder Dolland had only begun to taste the sweets of prosperity: while engaged intensely in the perusal of a new memoir of Clairaut, he was, on the 30th November 1761, struck with a fit of apoplexy, which in the space of a few hours hurried him to the grave.

The theory of Achromatic Telescopes was now complete, but it still required patience and address to carry it into successful execution. Dolland, and his son afterwards, took incredible pains in choosing their samples of glass, and acquired such exquisite skill in combining them, as to set all rivalship at defiance. The Continental Mathematicians were eager in examining the structure of those achromatic lenses, and in applying their superlative powers of calculation to define the proper forms. Klingenstierna and Boscovich, but especially D'Alembert and Euler, distinguished themselves by their most elaborate and profound investigations in this new branch of Dioptrics. Yet it may be questioned whether artists have derived any real help in practice from such vast and profuse displays of analytical research. England, following a more tentative procedure, continued exclusively for half a century to supply the world with Achromatic Glasses.

The correction of colour obtained by the ingenuity and perseverance of Dolland consisted thus in the blending of a spectrum with another of the same reversed length, but caused by an inferior refraction. Though the extreme boundaries were necessarily white, it did not however follow that the intermediate portions should be absolutely colourless. On the contrary, it seems ascertained that not only the entire expansion of the spectrum, but the relative extent of its several coloured spaces, depend on the peculiar quality of the refracting medium.

A redoubled combination of lenses might therefore mingle and destroy the secondary colours scattered through the middle range. But the light would be necessarily enfeebled by suffering those repeated refractions.

Several experimenters, in their attempts to improve the achromatic telescope, had proposed the interposition of fluids between the pieces of the compound object-glass. But the late Dr Robert Blair instituted the most elaborate investigation on this subject about the year 1787. He found all the essential oils, but especially certain metallic solutions in muriatic acid, to possess the greatest dispersive powers. A most complicated arrangement of those fluids with different lenses was first tried, and next abandoned for a less intricate combination of a triple muriatic solution, inclosed in glass shells, and invested on both sides by a semiconvex and a meniscus of crown glass. This compound appeared to produce the effect desired, not only discharging from the image the extreme fringes of red and violet, but excluding also the intermediate streaks of green and yellow. Unfortunately the liquid by degrees lost its transparency, either from the change of its own constitution or from the slow but continual corrosion of the surface of the glass. A similar attempt has been lately revived, but we fear with no better prospect of success. No confidence can be placed in the permanent transparency of any fluid medium.

Although the prismatic colours follow the same invariable order, they yet expand in very different proportions, according to the nature of the refracting substance. It is impossible, from the closest examination of the solar spectrum in a dark room, to distinguish the limits of the several coloured spaces, which appear to melt away by insensible gradations. The extreme boundaries of illumination are still more undefined. The red seems to graduate near the edge into a dull brown, while the violet spreads out by lengthening shades into blackness. Those verges are no doubt more extended in our climate, owing to the greater profusion of lateral rays sent from the white portion of the sky which encircles the sun's disc.

Three primary colours—red, green, and violet—are commonly supposed to be sufficient by their various admixture to generate all the rest. Thus, red mingled in different proportions with green produces orange or yellow, and green suffused with violet gives blue; while red blended with violet forms crimson, that fine brilliant hue which is not emergent in the solar spectrum. In this pencilled expansion, we may thus reckon three principal colours, or more completely four, five, or six, with innumerable shades. If the whole extent of the spectrum produced by a prism of flint glass be reckoned 50 parts, the spaces occupied by the unfolded colours will be nearly represented in this series: red 5, orange 4, yellow 7, green 9, blue 10, and violet 15; or if the orange be merged in red, and the yellow in green, the expanse of the four resulting colours will be, red 9, green 16, blue 10, and violet 15. These successive spaces are all considerably different, it must be confessed, from the fanciful subdivision of the diatonic scale of music attributed to the range of the spectrum formed by water or crown glass.

It is often assumed that the numbers of the component rays of light are proportional to the breadths of the several coloured spaces of the spectrum. But the most ordinary experience contradicts that supposition; for the eye is offended by the excessive glare of red and orange, is relieved by the softness of green, and feels languid under the feeble action of blue or violet. Whatever may be the distinctive properties of the coloured particles themselves, they are evidently collected by the prism in groups of very different densities. It is hardly possible to compare the various intensities of such heterogeneous things as colours with any degree of precision; but when highly condensed, the impression they make on the eye is nearly the same as that of white light itself. On this principle the late ingenious Fraunhofer, the great improver of achromatic glasses, was enabled in 1814 to estimate nearly the illuminating powers of the prismatic rays, by examining them as concentrated in the field of a large telescope of a theodolite. He found the brightest spot on the spectrum of flint glass to lie on the verge of the yellow next the orange, and about 11 parts of its whole extension of 50, from the extremity of the red. But the most remarkable discovery he made was, that though the coloured spaces appear not parted by any distinct boundaries, yet they are broken and subdivided by numerous white and black lines, or even dark stripes. He reckoned altogether above 600 lines; a few occur in the red, but they are multiplied in the orange, the yellow, the green, and the blue. A stripe, opened by a fine white line, divides the red; other stripes emerge at intervals between the orange and the blue; and two very broad approximating bars cross the violet. Other glass prisms, and even those filled with liquids, gave similar appearances, which were therefore not accidental, but the constant results of some law of nature. The powers of refraction thus advance not by insensible gradations, but seem to ascend with irregular bounds. This inference bears some analogy to the Newtonian hypothesis of the easy fits of reflexion and transmission.

The same judicious philosopher, combining eminent practical skill with deep and accurate science, succeeded by unwearied application in achieving the grandest improvement effected in the construction of achromatic glasses since the time of Dolland. Fraunhofer conducted personally the whole train of a large establishment; he directed the preparation and fusion of the materials, selected the proper pieces for grinding, and prescribed the due forms. The glass produced under the patronage of the liberal Bavarian government greatly surpassed in quality every other kind: It had a translucid purity, and a uniform consistency. Fraunhofer constructed with it the most perfect object-lenses, of more than eight times any former dimension, and exceeding nine inches in diameter. He had proposed to attain an aperture of ten inches or even more, and would unquestionably have succeeded, if death had not prematurely stopt his ardent career. The power and brilliancy of such magnificent telescopes transcended all conception.[1]

If the rays of the coloured spaces of the spectrum be so widely diversified in their illuminating energy, they differ no less in the property of exciting or communicating heat. Common language betrays in this respect their distinctive characters. Red and orange are termed warm colours, green temperate, and blue and violet are said to be cold. The first that endeavoured to measure the heating powers of the coloured rays of the spectrum was the Abbé Rochon, who in the summer of 1776 employed for that purpose an air thermometer and a prism of flint glass. But though he used some precautions, and repeated his experiments, the results were not very nice or consistent. Without venturing to compare the calorific intensities of the extreme rays, he yet reckoned those of a bright red as about eight times more powerful than such as gave the liveliest violet, and considered the bordering orange as the hottest spot in the spectrum. But in this country the differential thermometer, modified as a photometer, being an instrument susceptible of incomparably more precision, was applied to the spectrum of flint glass in 1798. Dividing the whole extent into four equal spaces, the calorific energies of blue, green, yellow, and red might be represented with tolerable exactness by the series of square numbers 1, 4, 9, and 16. Two years afterwards the famous Dr Herschel tried to measure the impressions made by the coloured rays on the small bulb of a mercurial thermometer, and arrived at the paradoxical conclusion, that the hottest part lies even on the outside of the red, and at a little distance beyond the extreme termination of the spectrum. It was thence inferred that there are dark rays which give only heat and not illumination, and travel in company with the solar beams, though less subject to refraction. This bold hypothesis was for a time regarded with wonder and applause; but the delicate observations of Berard, by the help of an Heliostate to direct the incident rays and give them a steady effect, soon demolished the fabric. A large circular prism or the outer ring of a huge burning glass has been since employed to mark with nicety the limit of the greatest calorific effect, which always occurs *within* the red space, though nearer its exterior border. The notion of dark rays of light, which enveloped the science in mystery, stands now therefore without any proof, and is utterly discountenanced by sound philosophy.

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[1] The Bavarian flint-glass appears free from those wavy lines or streaks which still impair the best English specimens, and displays besides one-third more of dispersive power. The famous telescope constructed for the University of Dorpat has an aperture of 9½ inches, with a focal length of 14 feet 3 inches English measure: it turns with a double parallactic motion, guided by the constant revolution of a centrifugal pendulum. This wonderful production of art, pouring a flood of light on the image, magnifies 200 and occasionally 600 times, and has enabled Professor Struve to augment prodigiously the catalogue of double and changing stars.

The improvements made in the application of Optics to the measuring of angles, since the invention of the repeating circle, relate principally to the micrometer. Bouguer proposed his *Heliometer*, or double object-glass micrometer, in 1748; but Short and Dolland, probably from a different suggestion, simplified the contrivance in 1754, by dividing a single object-glass into two equal portions. Beccaria had shown that rock crystal, like Iceland spar, has the power of double refraction; and Rochon availed himself of this property to construct in 1777 a very delicate micrometer, though Boscovich about the same time appears to have conceived a similar idea. Dr Maskelyne had more than a year before pursued a path little different, his micrometer consisting of movable glass prisms.

The French have ingeniously directed the principles of Optics to the improvement of Light-Houses. In this useful pursuit the celebrated Buffon led the way. Endeavouring to realize the performance ascribed to Archimedes, he disposed 400 mirrors, each of them half a foot square, into a frame, so as to collect the sun's rays into a single focus, and by the reflexion from this large surface in 1747 he actually set fire to wood at the distance of 70 yards. The experiment was next inverted, and a burner placed in the focus, to have its rays thrown parallel, and produce remote illumination. But for this purpose a much smaller reflector was sufficient, composed of bits of mirror planted in a spherical cavity. The final improvement consisted in hammering thin plated copper into a parabolic shape. These powerful reflectors, combined with Argand's lamp, were about thirty years since introduced from France into our light-houses.

Buffon tried likewise to concentrate the power of refracted rays. The ancient engravers had employed spheres of glass or crystal to assist vision; but the substitution of lenses, which at the close of the thirteenth century served for spectacles, was an important advance. This figure greatly reduced the thickness of the diaphanous mass, and therefore facilitated proportionally the passage of light. But the progress of improvement seemed completed in the plan proposed by the French Naturalist to obtain the exterior surfaces of a lens by combining a number of circular prismatic segments. From the difficulty of the construction, however, this project was long retarded, and afterwards forgotten. The knowledge of such attempts was not wanted to direct the ingenuity of Fresnel[1] into the right path. He calculated the curvature of the successive concentric segments which would produce a correct focus, and advanced the construction to a regular system, on which Soleil, an expert optician at Paris, has founded a manufacture. This compound lens has displaced the reflectors from the French light-houses, and must soon, from its very superior power of concentration, become generally adopted.

The eighteenth century created a new branch of optical science, destined to measure or compare the intensities of different lights, and therefore termed *Photometry*. The first notions of this curious subject were given by Marie, a French Capuchin, in a small tract printed in 1700. Though this ingenious person erred egregiously in the mathematical deductions, he had probably the merit of setting to work the superior talents and skill of his countryman Bouguer, who published in 1729 an original treatise *on the gradation of light*. He there sets out from the obvious principle that light darting in straight lines must become dilated or attenuated in the ratio of the square of the distance from the radiant source. But the eye with a little training can with tolerable accuracy distinguish in a dark room when two surfaces presented at once are equally illuminated, and consequently the relative powers of the lights may be readily computed from the distances required to produce such a congruous appearance. Bouguer compared the light of a candle with the dazzling brilliancy of the sun and the soft radiance of the moon; and found that the intensity diminishes from the centre to the margin of the solar disc, but that the gradation is inverted in our satellite. He discovered also experimentally the diminution of the sun's rays in traversing the atmosphere with different angles of obliquity. The same able experimenter ascertained the loss of light, as occasioned under different circumstances, by reflexion and refraction. He then held the office of Royal Hydrographer at Croisic in Lower Brittany; but after his return from the laborious and memorable scientific expedition to Peru, he resumed his early pursuits, and prepared an enlarged edition of his optical work, which was edited by Lacaille in 1760, two years after his death. At the same time came out the systematic treatise which Lambert entitled *Photometria*, designed as the sequel to a small tract which this ardent and inquisitive philosopher had printed two years before on the *remarkable properties of the route of light through the air*. This production is very complete in its mathematical structure; but the experiments on which it rests are generally not so well devised or so nicely performed as those of Bouguer. The ingenious author seems to confide too much in a sort of filtration and adjustment of facts, as obtained by the aid of calculation. Lambert, in his preamble, admits the imperfection of those observations, owing to the infirmity and variable condition of the eye, and regrets that he had no instrument like the thermometer to guide the sense of vision.[1] This desideratum was happily supplied before the close of the century; and the Photometer constructed on the principle of the minute differences of temperature is not only very delicate, but exempt from the remotest chance of error. The method of shadows proposed by Count Rumford in 1796, may be reckoned an improvement on Bouguer's procedure, but it is liable to the insuperable objection of depending altogether on the patient attention of the observer and his uncertain sharpness of sight.

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[1] The insidious advance of a consumption has arrested his career of discovery, and drawn that inventive and amiable philosopher to a premature grave.

The present century opened with the most auspicious prospects, and was soon distinguished by one of those great and unexpected discoveries which form an epoch in the progress of science. Such may be regarded the fine detection of the *polarized rays* of light by Malus, a French officer of Engineers, and one of the most ardent disciples of the Polytechnic School; which in so short a period drew together and put into rapid motion a far greater mass of mathematical and physical talent than any of the older seminaries in Europe. The double refracting property of Iceland Spar, or the crystallized carbonate of lime, noticed by Bartholinus and accurately investigated by Huygens, had likewise engaged the penetration of Newton, who concluded that the ray which suffers the *unusual* or *extraordinary* refraction must have its opposite sides affected by some virtue like magnetism which gives them a tendency to polarity.[2] This curious and acute remark appears to have lain neglected near a hundred years among the crowd of ingenious speculations started in the optical queries. Malus had early turned his attention to the more difficult problems in optics, and after his return, with a shattered constitution from an absence of several years spent in foreign service, obtaining more congenial employment at home, he resumed with enthusiasm his favourite studies, and devoted to them every moment he could spare. While intensely occupied with the investigation of the phænomena of double refraction, a fortunate accident occurred, which disclosed to him a new and splendid field of contemplation. In one of his frequent visits to the Observatory, during his residence at Paris, he chanced in the summer of 1809 to be struck with the brilliant reflexion of the setting sun from one of the windows of the Luxembourg Palace, on looking at the appearance through a prism of rock crystal which he slowly turned round, and remarked with surprise that one of the images changed regularly to brightness from obscurity. Next morning he repeated this observation with the same results, and soon found that light reflected at a certain angle from the surface of glass acquires the same character as the extraordinary ray in the double refracting prism. Water showed a similar disposition, but at a different angle of incidence. It was not difficult to trace the law through the various reflecting surfaces; but Malus extended his researches farther, and pursued them with rapidity and success. But, in the midst of this career, he was prematurely carried away from his friends and the philosophic world, by a lingering disease, on the 23d of February 1812. The subject of *Polarity* has been since carried forward by several eminent experimenters both abroad and at home, particularly by Arago, Biot, and Fresnel, and by Brewster, Seebeck, and Herschel; but it still wants the simplicity and evidence which always mark the perfection of science.

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[1] *Optandum certe esset, ut excogitaretur* Photometrum *thermometro analogum, quod lumini expositum ejus intensitatem atque claritatem indicaret.* He subjoins, *Enimvero ipse oculus ejus sistit exemplar, quippe pupillæ apertura luminis sequitur magnitudinem ac claritatem, et utrique sese accommodat. At magnopere dubitandum artem in hoc negotio naturam posse imitari.* (Photometria, sive de Mensura et Gradibus Luminis, Colorum, et Umbræ, p. 7.)

[2] The whole passage deserves transcribing. "The unusual refraction of island crystal looks very much as if it were performed by some kind of attractive virtue lodged in *certain sides* both of the rays and of the particles of the crystal. For were it not for some kind of disposition, or virtue, lodged in some sides of the particles of the crystal, and not in their other sides, and which inclines and bends the rays towards the coast of unusual refraction, the rays which fall perpendicularly on the crystal would not be refracted towards that coast rather than towards any other coast, both at their incidence and at their emergence, so as to emerge perpendicularly, by a contrary situation of the coast of unusual refraction, at the second surface; the crystal acting upon the rays after they have passed through it and are emerging into the air, or, if you please, into a *vacuum*. And since the crystal by this disposition or virtue does not act upon the rays, unless when one of their sides of unusual refraction looks towards that coast, this argues a virtue or disposition in those sides of the rays, which answers to and sympathizes with that virtue or disposition of the crystal, *as the poles of two magnets answer to one another*. And as magnetism may be intended or remitted, and is found only in the magnet and in iron; so this virtue, of refracting the perpendicular rays, is greater in island crystal, less in crystal of the rock, and is not yet found in other bodies. I do not say that this virtue is magnetical; it seems to be of another kind: I only say, that whatever it be, it is difficult to conceive how the rays of light, unless they be bodies, can have a permanent virtue in two of their sides, which is not in their other sides; and this without any regard to their position to the space, or the medium, through which they pass." (*Optics*, book iii. query 29.)

6. DOCTRINE OF HEAT.

HEAT is the great principle of all internal motion. Its various changes and gradations determine the growth of plants and the expansion of animated beings. The knowledge of the production of fire was the earliest of human discoveries, and already distinguished our species in its lowest condition from the brute tenants of the forest. The application of that element has most essentially contributed to the advancement of the arts and the general progress of society. It has contributed prodigiously to the increase of population, by converting the crude produce of the soil into nutritive and wholesome aliments. Applied in a higher degree, it has aided industry in fashioning the various utensils necessary for the comforts of life; but urged to the greatest intensity, it has enabled man to fuse the metallic ores, and forge those efficient tools by which he controls the powers of nature, and renders them subservient to his convenience. What a vast interval in the range of progression from the rude savage, that laboriously kindles two sticks by rubbing them, to the experienced engineer, who combines all the deductions of philosophy in wielding and directing the resistless force of steam!

The Doctrine of Heat has, in the course of the eighteenth century, been advanced to the rank of a science. Its transfusion through the mechanical arts has communicated a grand movement to society, and wonderfully augmented our national wealth and resources. That a subject so nearly concerned with the wants and comforts of human life should have remained during the lapse of ages in a state of mere infancy, might furnish matter for grave reflection. The science is essentially experimental, while the ingenuity of the ancients was expended in framing loose and airy visions. Fire they held to be the Fourth Element, which, by its extreme levity, soared to the highest place in the Heavens, and spread its lambent ethereal essence over the boundless regions of space. Being regarded of pure divine origin, the sparks of the celestial flame were believed to impart animation to the beings of this nether world. But the Heat which commonly pervades the terrestrial bodies, and feeds our culinary fires, was considered by the sages of antiquity as variable in its constitution, and of a lower and perishable nature.

Heat was viewed by Aristotle as a peculiar element, composed of minute particles in continual agitation. Bacon, after a very prolix and confused exemplification of his formal method of pursuing induction, arrived at a conclusion nearly similar, though less intelligible, that Heat consists in a certain expansive motion. But other philosophers, and especially the alchemists, entertained juster notions of the subject. They conceived Heat to be a material substance, of extreme subtilty, diffused in various proportions internally through all bodies. Unfortunately those theorists were not very consistent in their speculations. The different applications of fire they considered as not merely varying in degree, but quite distinct in kind. The heat of a furnace and a stove, that of a sand and a water bath, and that of putrefaction and fermentation, seemed in their apprehension all separate species; and animal heat was regarded by the Arabian physicians as a finer essence, endued with invigorating and restoring virtue.

So long as such notions prevailed, it is evident that no real advances could be made in the knowledge of the properties of Heat. The first thing required was to find a method of ascertaining its intensity; and for this invention we are indebted to Sanctorio, Professor of Physic in the University of Padua, the celebrated discoverer of Insensible Perspiration, who, near the end of the sixteenth century, laboured with ardour and success in improving Medical Science by the application of Mechanics. Hero, of the Alexandrian School, had anciently described a curious machine, which, by the alternate expansion and contraction of included air during day and night, produced certain reciprocating motions; the Paduan physician seized the principle, and constructed an instrument on a small scale, chiefly adapted to measure the temperature of the human body during fevers. It consisted of a pretty large ball of glass, terminating in a long narrow stem, which was inverted and plunged perpendicularly in water or coloured liquid. For the sake of convenience, the ball was sometimes flattened on the one side, and the stem rendered more compact by serpentine involutions. With this instrument Sanctorio tried to measure the heat of the rays shot from the sun, and even that of the lunar beams, which were fancied then to have a gelid influence.

The *Air Thermometer*, as it is now called, was about twenty years afterwards, though probably without any communication, reproduced by Drebbel of Alcmaer in North Holland, who carried it, with other ingenious contrivances, into England during the latter part of the reign of James I. The instrument being observed to be affected by the changes of weather, was hence called a *Weather Glass*. In fact, it indicated only the elasticity of the air, which depends on the blended operation of two separate causes, the degree of temperature, and the varying force of atmospheric pressure. But the latter influence was yet unknown, nor till the great discovery of the Barometer by Torricelli could it be distinctly traced. The insufficiency of the Air Thermometer was then perceived, and another fluid substituted, which sensibly expands by heat while secluded from the compression of the atmosphere. The Florentine Academicians, about the year 1655, first constructed an instrument of that kind, consisting as before of a glass ball, but filled with spirit of wine, and having its stem of a smaller bore, sealed hermetically, or melted at the top by the flame of a blow-pipe. Italy had thus the honour of inventing both those instruments, the Thermometer and Barometer, the most important auxiliaries of modern science. Three different forms of Thermometers, constructed for the *Academy del Cimento*, were copied and circulated over Europe. But the great object now was to procure an exact correspondence, by fixing on some standard scale. The Italians began the divisions at the cellar heat, supposing this to be uniform; and they marked other points by plunging the ball in certain chemical mixtures. Boyle proposed the freezing of the oil of aniseed for the lower point; and Halley recommended the ebullition of alcohol as the limit of the scale. The great advantage of deriving a point from the congelation of water was not at first perceived. Many observers believed it to vary under different circumstances, being deceived by the fact that water will bear a greater cold before it shoots into crystals, though the temperature at which ice or snow begins to melt is always the same. Guericke was the first who started from the thawing point, in dividing the scale of a large spirit of wine thermometer. To regulate the divisions, two different ways occurred; either to assume a higher point, or to distinguish into small portions the capacity of the ball. The latter was the mode adopted by Newton, who recreated his mind with chemical experiments. Employing linseed oil, which expands largely, and bears a great heat, he subdivided the capacity of the glass into 10,000 equal parts; and beginning from the point of thawing ice, he found the liquid to expand 256 at the heat of the human body, 725 at boiling water, and 1516 at melting tin; but preferring smaller numbers, he assumed 12 for blood heat, and reduced the other numbers in the same proportion to 34 and 71. This method was quite philosophical, but of very difficult execution. A correct and ingenious process for determining the scale of heat was proposed in 1694 by Renaldini, a learned Italian mathematician. Taking the freezing and boiling of water for the extremes, he found the intermediate points from a mixture of ten parts, composed progressively of melting snow and water just ceased from ebullition, the ingredients being 1 and 9, 2 and 8, 3 and 7, &c. About twenty years afterwards, Brook Taylor and Hauksbee applied that ingenious mode to ascertain whether the expansions of certain fluids are exactly proportional to the corresponding accessions of heat.

It had been proposed by Roemer to fill thermometers with quicksilver, and Halley adopted the suggestion. But instruments of this kind being observed to disagree with the common spirit of wine thermometers, the cause of such discrepancy was now detected. Alcohol swells with increasing progression on the application of heat; while mercury shows the valuable property of expanding with an uniform advance.

After the point of thawing snow had been fixed, the degrees of the scale were generally derived from the decimal subdivision of the capacity of the ball. But this absolute bulk is not the true basis of the scale, since the expansion indicated by the thermometer must be the excess of the dilatation of the liquid above that of the glass which contains it. The mensuration of the ball hence became troublesome and liable to much uncertainty.

The first who succeeded in constructing thermometers with adequate skill was Fahrenheit. This ingenious man had been a merchant at Dantzic, and through misfortune failed in business; but having a good taste for mechanics, he removed into Holland, and settled as a philosophical instrument maker at Amsterdam. He began with spirit of wine thermometers, which he formed much smaller and neater than had been attempted before. But he soon preferred quicksilver, and having found it to expand from freezing water to blood heat, about 60 parts in 10,000, he assumed the number 64, and obtained the degrees by repeated bisections. In this practice he was confirmed, on observing what he considered as extreme cold, to descend just through half that space, or 32 degrees. From a mixture of water, ice, and sal ammoniac, the scale commenced; 32 degrees were allotted for the interval to ice-water, and 64 more for the ascent to blood heat. But he afterwards enlarged the range, and assumed another point from the limit of boiling water, which he placed at the 212th degree in the mean state of the atmosphere, though liable to some variation from the change of barometric pressure. Such was now his confidence in the delicacy of the construction, that he proposed the thermometer as an instrument for ascertaining the heights of mountains from the depressed temperature of boiling water; a very simple method, which has been lately revived by the reverend Mr Wollaston.

The thermometers manufactured by Fahrenheit being remarkably neat and convenient, were, notwithstanding their arbitrary subdivision, widely dispersed over Germany, and introduced into Britain by the practitioners in physic, who at that period usually resorted to Holland for medical instruction. But most strangely in France a very unwieldy and inaccurate instrument maintained its ascendancy. The thermometer of Reaumur had a ball near four inches in diameter, which was filled with spirit of wine diluted with water. The scale began at the term of congelation obtained by an artificial process, but the highest point was marked by plunging the instrument into boiling water. But it is evident that the liquid could never reach this degree of heat, but would stop several degrees lower at the limit of its own ebullition. Besides, so large a mass receiving the impression very slowly, would not indicate with any precision the temperature of the surrounding medium. Reckoning the ball to contain 1000 parts of the fluid, the whole expansion was found to be 87½, and Reaumur therefore took the round number 80 for the extent of his scale. The same artificial subdivision is still very generally retained, though transferred to the mercurial thermometer, which is exempt from the glaring defects and errors of the original instrument.

Provided with Fahrenheit's thermometer, the philosophers of Holland and Germany made some progress in the science of heat, while France appeared to rest satisfied with mere speculation. But experimenters were too eager in hastening towards general conclusions. While the theory of gravitation possessed the charm of novelty, it seemed natural to suppose that heat is distributed among bodies according to their density or mass. This inference, however, is often very remote from the fact. Boerhaave found that a pound of mercury at 200°, so far from communicating to a pound of water at 32° half the excess of heat, or 84°, as another pound of water at that high temperature would have done, gave only an addition of 4°; so that twenty pounds of mercury had scarcely as much heating influence as a single pound of water. It would have required, according to his experiment, even a greater bulk of mercury by one-half more, to produce the same calorific effect as water. Had he performed the process with due precaution, he might have observed that hot water exerts as much influence as mercury of 32 times its weight or 2⅓ times its volume. But this celebrated chemist, satisfied with gross results, and mistrusting perhaps his own experiments, hastened to the conclusion *that heat is distributed among bodies in proportion to their bulks*, or *maintains an equal diffusion through space*. This principle was likewise adopted by Musschenbroeck, and the simplicity of the proposition seems to have procured it a very general reception.

Wolfius, who about this time was spatiating over the vast field of physical and moral science, and forming a new philosophical sect in Germany, taught that bodies had two sorts of interstices, the one filled with air and the other charged with fire. He attempted to explain why iron acquires heat sooner than wood, and why the solution in nitre occasions cold; but neglecting to follow experiments, he produced only vague and shallow speculation. Equally visionary, but enlivened by French vivacity, was Mairau's *Dissertation on Ice*, published in 1740.

The most judicious writer that had yet appeared on the subject of heat was Dr Martine[1] of St Andrews, who studied medicine on the Continent, and, like the accomplished physicians of that period, cultivated learning and general science. His acute Essays, published in the years 1739 and 1740, not only corrected the different thermometric scales, but enriched philosophy by several well-devised and original experiments. Unfortunately the career of this promising genius was very short. Having in the pursuit of his profession accompanied Admiral Vernon in the fatal expedition against Carthagena, he perished by a malignant fever. Martine did not consider with sufficient attention the unequal distribution of heat among bodies, but he carefully investigated the variable rates of heating and cooling of different substances. He noticed especially the facility with which mercury, in comparison of water, receives or parts with its heat. He conceived the process of cooling to be commonly retarded by a sort of covering or atmosphere of warm air closely encompassing the body; and he endeavoured to distinguish two sources of the dispersion of heat. Had such investigations been steadily prosecuted, they must have led to interesting results.

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[1] He was the son of George Martine, a small Fife proprietor, who having officiated as chamberlain to Archbishop Sharp, wrote a credulous and bigoted account of the See of St Andrews. The youth displayed the principles of the defunct Episcopacy, by heading a riot of some students at the College of St Andrews, on the breaking out of the feeble rebellion in 1715.

About this time, the practice of making observations with the thermometer had become pretty general in England, in consequence of the diffusion of the very neat and accurate instruments manufactured by Fahrenheit and Prins, at Amsterdam, which were likewise imitated in London by Wilson, who afterwards established a flourishing type-foundry at Glasgow, and held the professorship of Practical Astronomy. These thermometers were filled with quicksilver, and only four or five inches long, the stem clasped by a folded paper scale, engraved with successively bisected divisions, and the whole inclosed in a thin glass case. But the most philosophical construction of the thermometer was now proposed by the learned Celsius, who filled the chair of Astronomy in the University of Upsal, and had borne an active share in the operation of determining a degree of latitude on the verge of the Arctic Circle. He started from the point of congelation, and reckoned just a hundred divisions upwards to that of ebullition. This simple scale, commonly used in Sweden and Denmark, is the same as that which was afterwards adopted by the French under the name of *centigrade*, in their complete and elegant system of decimal weights and measures. It is singular that Deluc, in rectifying Reaumur's thermometer, should have retained such an artificial subdivision as that by fourscore. But this philosopher had the merit of ascertaining that mercury dilates almost uniformly with equal additions of heat, while the expansion of the spirit of wine is variable, and ascends with an accelerating progression. A thermometer formed of alcohol, whether diluted or not, is hence exceedingly inaccurate, unless it be regulated by the comparison with a mercurial one.

The practice of using thermometers filled with quicksilver led to the curious discovery of the congelation of that dense liquid. Professor Gmelin, who had been sent with a party of naturalists to explore the remote regions of the Russian empire, observed in Siberia, on the 16th of January 1735, the mercury to sink in the thermometric tube to a point which corresponds to the 120th degree below the zero of Fahrenheit's scale, while it changed into a solid mass. But the artificial freezing of mercury was first performed by Braun, Professor of Philosophy at Petersburg, in the month of December 1759, when the natural cold seemed to be 34° under the beginning of the scale. Having plunged the bulb of a thermometer into a mixture of pounded ice and sal ammoniac, the quicksilver appeared to sink progresively to 350°, and then to consolidate. But such enormous cold exceeded the bounds of credibility, and Æpinus soon discovered the source of this illusion. Employing tubes of a wider bore, he observed the quicksilver, drawing after it a concave surface, to retreat as it congealed, and sink into the rest of the liquid mass. The semi-metal must therefore have suffered a large contraction in the act of freezing, and become much denser. Yet twenty years elapsed before the point of mercurial congelation was correctly ascertained. On the 16th of January 1780, Von Elterlein of Vytegra, a town of Northern Russia, in the latitude of 61°, found that some pure quicksilver exposed in a porcelain tea-cup during the night had become solid, but began to melt again when the thermometer rose to 40 degrees below the zero of Fahrenheit's scale. This limit was more decisively fixed, at the suggestion of Dr Black, by Hutchins, then governor of Hudson's Bay, who repeatedly froze mercury during the winter of 1781–2, by the application of artificial cold. In rigorous climates, or for measuring very depressed temperatures, it hence becomes necessary to employ thermometers filled with alcohol, which has never been made to freeze.

The cold occasioned by the evaporation of water and other liquids in the more genial regions had been known and turned to domestic use from the earliest ages. In the northern countries, that property, being less apparent, was commonly disregarded; but the thermometer now detected changes which might elude ordinary observation. It was soon remarked that, after dipping the bulb in water or alcohol, the quicksilver constantly sunk in the stem. About the year 1750, Dr Cullen, then Lecturer in Chemistry at Glasgow, in repeating some experiments with a pupil, remarked that a thermometer with a wetted bulb showed a much greater depression of temperature under the exhausted receiver of an air-pump. But he did not pursue the observation farther, or attempt to investigate the theory of evaporation. This interesting subject remained long afterwards involved in deep obscurity.

The temperature of water exposed to heat appears to rest stationary at the two distinct limits of freezing and boiling, which serve to mark the points of the thermometric scale. Though the fact had been long well known, it was first examined with attention in 1760 and the three following years by the celebrated Dr Black, who had already distinguished himself by unfolding the nature and properties of fixed air. He rightly inferred that a certain additional share of heat must at each station unite with what is already lodged in the substance of the ice or the water; but not aware that he was really framing an hypothesis, he termed the former *latent* and the latter *sensible* heat. Strictly speaking, however, all heat is latent or concealed from the senses, and never exhibited in a detached form. The thermometer indicates merely the heat contained in its own bulb, and not necessarily that of the body with which this communicates. "But heat is evidently not passive; it is an expansive fluid, which dilates in consequence of the repulsion subsisting among its own particles; and it would spread indefinitely through space, if it were not fixed or retained by the counterbalancing attraction of the substances which absorb it. Were each corpuscle to exert the same action, this universal fluid would be disseminated among bodies, exactly in proportion to their respective quantities of matter. The mutual adhesion depends, however, on the density of the substance, modified by its degree of inherent disposition to combine. A sort of affinity or specific attraction for heat is thus produced, evidently proceeding from the peculiar nature of each body. To trace its immediate origin is not more possible perhaps than to discover the source of other physical properties. Yet there appears some tendency towards a general principle: the particles of heat, like those of all expansive fluids, have their repulsion diminished in proportion to their mutual distance; while the molecules of the containing substance suffer the corresponding decrease of attraction after a slower ratio than the spaces of internal separation. Heat has therefore a narrower range of density than the bodies with which it combines. It holds a sort of middle station, and is distributed according to the quantity of matter, joined to the consideration of the space which this occupies; that is, it obeys some compounded relation of the weight and the bulk. Hence the denser bodies receive a proportionally smaller share of heat. Thus, a pound of metal contains less heat than one of stone; this, less than an equal weight of liquid; and this last, still less than a pound of any species of gas."

"When two bodies are united chemically, the compound has an attractive force generally different from that of the mean result. Hence a corresponding portion of heat is, during the act of coalescence, either absorbed or evolved. Thus, water, on being joined to sulphuric acid, occasions an extrication of heat, because the diluted acid exerts less power of adhesion than did its ingredients. And, for an opposite reason, the muriate of ammonia, in dissolving, is attended by an absorption of heat, or an apparent production of cold."

"Every substance capable of assuming different states of constitution betrays likewise analogous variations of attractive force. When a solid body melts into a fluid, and thence passes into vapour, each transit is marked by an augmentation of that force, and is therefore accompanied with a corresponding absorption of heat; during which process, the temperature must evidently remain stationary. Thus, a lump of ice transported intensely cold into a close apartment, will grow warmer by regular gradations, till it begins to thaw, and then the farther accumulation of heat will appear to be suspended; and if the water so formed be poured into a covered pot, and set over a steady fire, the temperature will again rise uniformly, till it reaches the limit of boiling, when the act of conversion to steam will henceforth absorb the whole affluent heat; yet the temperature will mount still higher if the escape of the vapour be prevented, but which soon acquires such prodigious elasticity as to burst whatever obstacle can be opposed to it."[1]

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[1] *Experimental Inquiry into the Nature and Propagation of Heat*, pp. 529–531.

The first that made any advance towards such views of the distribution of heat was Irvine, who had been assistant to Black at Glasgow. Unfortunately he seems to have introduced the term *Capacity*, which involves a crude notion, as if heat were merely passive, filling up the interior pores or internal vacuities of bodies. But, a few years afterwards, Wilcke of Stockholm, directed, he says, by the views of his colleague Klingensticrna, a mathematician and philosopher of the first order, examined the subject philosophically, and performed several accurate experiments. Thus, he found that water at 98° of Celsius, poured upon an equal weight of snow, had its temperature reduced to 13°, and that three parts of water at 40°, joined to one of snow, produced the common temperature of 12°. These trials gave both the same result, or 73° of Celsius, corresponding to 129·6° on Fahrenheit's scale, for the increase of heat required to convert snow into water.[1] A similar conclusion was obtained by filling equal tin vessels with equal parts of snow and snow-water, and placing these within a larger one full of boiling water, and set over a fire; the moment the chill water rose to 72°, the snow had all melted.

In 1780 Lavoisier, assisted by Laplace, and employing his *Calorimeter*, ascertained the heat evolved from different bodies during their various changes, from the several quantities of ice which it melted. This seemed to be a very simple and correct mode of investigation; yet was it liable to considerable inaccuracy, from the large portion of water which still remained adhering to the mass of pounded ice. But the French chemists rather confused the subject, by mixing up incongruous principles. Embracing the theory of *Capacity*, they likewise tacitly adopted the hypothesis of *sensible* and *latent* heat, only changing these terms by a sort of appropriation into *free* and *absolute*, while the poverty of their language suggested for that fluid such an imperfect etymon as *Caloric*.

The best series of experiments on the distribution of heat among different bodies was performed before the year 1784 by Professor Gadolin of Abo, who, rejecting the notion of *Capacity*, introduced the unexceptionable expression, *Specific Heat*. One of the most beautiful consequences derived from this theory, was the determination of the absolute zero or lowest point in the scale of Heat. Two different ways of solving the problem led to nearly the same results: 1. From the measure of Heat absorbed in the melting of ice, and 2. From the quantity evolved in the mixture of certain liquids. Thus, it being found that the heat contained in water is to that of ice as 10 to 9, and that 135 degrees are required for the equilibrium of the liquid constitution, it follows that the water just formed must actually contain 1350 degrees of heat, or that the real scale would descend to the enormous depth of 1318° below the beginning of Fahrenheit's divisions. Again, the concentrated sulphuric acid holding only six tenth parts of the heat of water, the arithmetical mean of a mixture of one part of it by weight with three of water would evidently be nine tenths; but suppose the specific heat of that compound were only eight tenths, while the thermometer rose on the affusion 169°, or from 32° to 201°, the whole extension below the point of congelation would be 8° × 169°, or 1352°. This experiment is susceptible of greater accuracy than the former, and deserves to be repeated in different proportions. Considerable discrepancies have hitherto affected such observations, arising probably from the want of sufficient precaution in the manner of conducting them.

Dr Crawford followed nearly the same train, and was enabled, by employing finer instruments, to obtain a greater degree of precision. He took, on the whole, a philosophical view of the subject, but sacrificed his better judgment to popular opinion, by retaining also the hypothesis of *Latent Heat*, "the ideas associated with which have spread a cloud of mystery and paradox most unfavourable to the progress of real science." It is to be regretted that a similar confusion of ideas should still pervade the writings of so many of the chemical philosophers. Crawford had expected much accuracy from thermometers with large bulbs and minute subdivisions; but these advantages were more than overbalanced by the want of delicacy to transient impressions. On a revision of the experiments from which he sought to ground his theory of animal heat, he had occasion to change the numerical results.

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[1] In the first experiment the hot water lost 98° — 13°, or 85°, while the snow water gained only 13°, or had absorbed 72°: in the second experiment the hot water had transferred 3 (40 — 12) or 84°, and consequently 84° — 12°, or 72°, was spent in liquefying the snow. If every precaution were used, the measure of heat absorbed would amount to 75° of Celsius, or 135° by Fahrenheit's scale.

About this time shone forth the brilliant and original genius of Scheele, who not only expanded the boundaries of chemistry by his various inventions, but enriched other departments of physical science. In particular, he bestowed a keen glance on the subject of the emission of Heat.

That Heat, and even the opposite influence, impression of Cold, admits of Reflexion, like light, is a property long known, and had been distinctly announced by Baptista Porta, in the sixth edition of his *Natural Magic*, printed about the year 1590. This remarkable experiment was more particularly described in 1632 by Cavalleri in his tract on the *Burning Speculum:* it was repeated and varied in 1658 by the members of the *Academy del Cimento*, who received the impression on the bulb of an air thermometer. The concentration of cold in the focus of a metallic reflector was again tried, during the severe winter of 1740, by the academicians of Petersburg, though with rather doubtful results, owing to their ignorance of the true circumstances on which the success depends. But, after an apparent oblivion of near forty years, the experiment was revived with striking effect at Geneva, and continues to hold a conspicuous place in every course of physical lectures.

Mariotte, as far back as the year 1682, had made a capital remark, which some late discoveries have revived and explained. That able experimenter, in concentrating the heat of a fire by help of a burning mirror,[1] found the effect to cease when a piece of glass was interposed behind the focus. A similar experiment was about the same time made by Hooke, though not published till very long afterwards. This ingenious philosopher showed that a glass mirror which reflects light will not repel heat. But these interesting facts lay buried for a century amidst a multitude of scattered observations, and seem to have first attracted the notice of Saussure and Pictet, both of whom, and especially the latter, carried the investigation to some extent. They still wanted the connecting principle, which should embody and reanimate the mass.

Scheele pursued a similar path, but was little versant in the history of science, and had none of the advantages of an improved apparatus. Endowed with original and inventive powers, he followed the current of his own conceptions, and consulted always the book of Nature. An examination of the circumstances disclosed in the management of stoves and chemical furnaces, induced him to consider Heat or Fire as existing under two distinct modifications; one which rises and spreads by a successive transfer among the ambient substances, and the other which streams immediately from its source in rectilineal directions. The latter he designated by the phrase *Radiant Heat*, which has since become a favourite appellation. If this expression indicated merely the *tendency* of Heat, under certain circumstances, to disperse in straight lines, it would be quite unexceptionable. But in technical language, the *Radiation of Caloric* associates an obscure idea of a subtile fluid invested with vague or uncertain properties.

The common thermometer comprises, between freezing and boiling mercury, the space of scarcely 700 degrees; which is evidently but a small portion of the vast range of heat. It was most desirable, therefore, to have an instrument of greater extent, adapted especially to the ascending scale. The *Pyrometer*, composed of metallic bars, answered, though very imperfectly, that purpose. But the elegant contrivance of Wedgwood, the celebrated improver of English pottery, promised the greatest advantages, both to science and the chemical arts. It consisted merely of a small cylindrical piece of finely prepared clay, which bears the most intense heat, and yet regularly contracts in the fire. Assuming that the intensity of heat must cause a proportional contraction, he measured this by sliding the thermometric piece within a tapered groove, its width at the one end being to that of the other as 5 to 3, and its whole length divided into 240 equal parts. By comparing the dilatation of silver, it was found that each of these divisions answers to 130 degrees of Fahrenheit's scale. Hence the melting points of silver, gold, and cast-iron, and those of the fusion of flint-glass and of Chinese porcelain, being respectively 28, 32, 130, 114, and 156, by Wedgwood, would correspond to the enormous numbers 4717°, 5237°, 17977°, 15897°, and 21257°.

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[1] This must have been a *metallic* reflector: an ordinary mirror, or one of silvered glass, will scarcely collect any heat at all. Indeed the art of applying a metallic plate to the surface of glass is a modern invention. The earliest method was the Dutch, which consisted in pouring melted lead intensely hot over a sheet of glass softened nearly to fusion. But the adhesion was afterwards more easily obtained in the ordinary way, by applying tinfoil to the glass, and dextrously flooding it with mercury, to form an amalgam. It is from this shining metallic coating that light is chiefly reflected, having penetrated and again escaped through the substance of the glass. But with regard to Heat, a very small reverberation takes place at the anterior surface of the glass, and the effect is exactly the same if the silvering be rubbed off. It would prevent much confusion were chemical writers to appropriate the term *speculum* to metallic reflectors.

These results, however, appear far to transcend the truth. The principle of the instrument is totally different from that of the thermometer. It does not mark the transient impression of heat, but the change or permanent effect produced on the bit of clay by *baking*, or the exposing it *during a certain time* to the action of the furnace. Hence the very ingenious method of discovering the degrees of heat which the Chinese and the ancient Etruscans employed in their potteries, by observing the moment when a specimen of their ware subjected to an increasing fire began to contract anew. That contraction is undoubtedly caused by the expulsion of a part of the water held so obstinately by the clay, the repulsive force excited by the accession of heat controlling the adhesion of the moisture. It may be inferred that the clay attracts the remains of latent humidity with a force always increasing; but the repulsion infused by the conversion of the expelled particles into steam ascends nearly in a geometrical progression with equal accessions of heat. A nearer approximation to the scale of temperature might probably be derived from the logarithms of the very large numbers stated above.

It remains however still an important desideratum to construct a thermometer that shall accurately measure the higher degrees of heat. The fusible metal, composed of lead, tin, and bismuth, has been suggested as an expansible substance, which may be heated to near the fusion of copper; but, in congealing again, it unfortunately swells suddenly, and would burst its glass ball. A combination of metallic bars has likewise been proposed, though no plan for effecting this has yet been devised, sufficiently simple and reducible to practice.

Metallic thermometers have indeed been constructed, which indicate with great delicacy the ordinary temperature, and all the sudden changes of heat. These consist generally of thin slips of steel and brass, united together, and formed into circles or spirals. The most elegant instruments of this sort were executed at Paris, by the late ingenious artist Breguet.

It was an object of much greater consequence to construct a *register-thermometer*, which should mark the greatest heat and cold during the absence of the observer. This had been attempted by different experimenters in the course of the eighteenth century, but was first carried to any tolerable perfection about the year 1780, by Mr Six of Canterbury. These registers consisted of spirit of wine thermometers, with compound reverted stems, partially filled with quicksilver, which carried small bits of steel to indicate the limits of ascent. With such instruments the inventor made some curious observations on *local heat*, or on the differences of temperature at moderate altitudes during the alternations of day and night. He particularly remarked the influence of a clear sky in chilling the ground.

The simplest and most commodious register-thermometers, however, were a few years afterwards contrived by Dr Rutherford, an ingenious physician, who resided on his property in the neighbourhood of Kinross. They turn on a pivot, the stems being placed nearly horizontal, and only reclined occasionally for adjustment after the heat of the day. The *minimum* thermometer is filled with alcohol, and the *maximum* one with mercury, the tubes of both being rather wide, with bits of enamel swelled at each end, which are drawn down the slanting tube by the retreat of the alcohol, or pushed upwards by the expansion of the mercury. Rutherford's thermometer was first happily applied by his neighbour Dr Coventry, the well-known

Professor of Agriculture in the University of Edinburgh, in ascertaining the progress of heat into the ground, and its effects on the germination of the seeds of the *cerealia*. Some curious facts have thus been detected regarding the influence of an herbaceous covering to retard the penetration of frost.

The thermometer soon afterwards received a most important modification, which renders that instrument extremely sensible to the alterations of local heat. This improvement consisted in adapting the instrument to measure, not the actual temperature of any spot, but its occasional change or variation. The extent of the scale being limited, the dimensions of the degrees could be proportionally enlarged.

The construction of the Differential Thermometer was early suggested by a close analysis of the phænomena of evaporation. It is well known that a wet sponge suspended in the air loses gradually its water, and during this dissipation it continues colder than the encircling medium. The depressed temperature was commonly attributed to a process of rapid evaporation, which seemed to result from the combined action of various causes,—the heat of the air, its state of dryness or rarefaction, but especially the swiftness of its circulation. Halley had, near the close of the seventeenth century, advanced the rational hypothesis, that moisture is exhaled from the surface of water by a sort of chemical solution in the atmosphere. The same opinion was about the middle of the following century proposed and expounded by Le Roy of Montpellier; but though supported by concurring analogies, it might appear perhaps too simple for the general taste. The fanciful notion, first started by Derham, that evaporation is occasioned by very minute vesicles or hollow spherules of water, charged with highly attenuated air, which rise and float in the atmosphere, proved more acceptable to a wondering public. The vesicular theory afterwards obtained a wide currency from the philosophical reputation of Saussure, who considered it as countenanced by some dubious optical appearances. But the mere subdivision of fluid matter could produce no change of temperature, and the clearest facts are opposed to the notion of a passive dispersion of aqueous corpuscles.

An absorption of heat always accompanies the passage of a fluid from the liquid to the gaseous form, which seems to require the same surplus, in whatever way the conversion has been produced. If a body of air be confined over a surface of water, it will soon become charged with moisture, and then there is no more evaporation. But if the damp air be suffered to escape and disperse itself, the process will be perpetually renewed. The corresponding abstraction or transfer of heat must consequently proceed without intermission. Although the dissipation of moisture and of heat from a humid surface exposed to a current of air continues incessant, the coldness thence resulting is not, however, likewise progressive. A wet sponge or a porous vessel full of water will, when placed in the same situation, gradually arrive at a certain depression of temperature; nor will this limit alter without a change of circumstances. It follows, therefore, that the exhaling surface, after it has become colder than the ambient medium, must begin to receive as well as to discharge heat. Every thin shell of air which successively comes to touch the humid surface must be cooled down to this standard, and thus deliver its excess of heat, while it absorbs another portion spent in vapourizing the moisture it dissolves. As the process of evaporation goes on, the heat communicated at each repeated contact of the fugacious medium must soon come to be precisely equal to what is again abstracted from the exhaling liquid in the act of saturation. When this equality of interchange is attained, the resulting temperature must have reached its lowest point of depression, where it will continue stationary. But the heat deposited by each successive shell of air must evidently be proportional to that depression, which will hence indicate the portion of humidity that passes into the gaseous state of solution; or the difference of temperature induced will furnish an accurate measure of the dryness or distance from saturation of the circulating air. To obtain, therefore, a perfect Hygrometer, it was only required to construct a Thermometer that should mark distinctly small differences of heat. In the first application of this principle, made as early as the year 1791, the water was evaporated from a thin porous earthen cup, like a truncated egg-shell; and the thermometer had rather a large bulb, with a very narrow bore, and bearing a scale of only a few degrees subdivided into tenth parts. The tube was not sealed, but had a wider cup of glass cemented a little below the top, containing some mercury, which united with that of the stem when the instrument was inverted, and separated the moment it was dipped into the evaporating cup, leaving the mercurial thread to contract downwards from the end. This arrangement was found, with due care and attention, to answer satisfactorily. It was more than three years afterwards, when the severity of the season suggested the idea of making the ball of the thermometer itself the evaporating surface, by covering it with a crust of ice.

The next advance was at all times to invest the ball with a thick coat of tissue paper or soft lint, that should hold a sufficient charge of water. To find the depression of temperature which marks the dryness of the air, nothing was wanted but to compare it with another thermometer having a naked bulb. This purpose appeared to be most easily effected, by joining the stems of two air-thermometers; and thus was fortunately produced the DIFFERENTIAL THERMOMETER, which under a variety of forms is capable of so many curious and important applications. Its primary object was to serve for an Hygrometer, but the instrument was soon found, when placed out of doors, to be sensibly deranged by the diffuse light of the sky. This circumstance led to its modification as a Photometer, the covering being removed from one of the balls, and the other ball blown of black enamel. The addition of a pellucid glass case now became necessary, to screen the action of light from the consuming and irregular influence of wind. The luminous rays pass without interruption through the clear ball, but are by the dark ball absorbed and converted into heat, which continues to accumulate and to raise the temperature, till the corresponding augmented dispersion of heat by the ambient air comes at length to equal the continued accessions from the afflux of light.

In arranging the instrument as an Hygrometer, it was hence requisite to neutralize the photometrical influence, by covering the evaporating ball with coloured silk, and blowing glass or enamel of the same shade for the naked ball. A free exposure to the atmosphere is in this case essential. The sweep of the wind may accelerate the equilibrium, but cannot derange its limit; for the same portion of air which abstracts vapour and the constituent heat, likewise deposits its excess of temperature on the chilled surface of the wet ball. The interposition of a screen will not in the smallest degree affect the indication of this Hygrometer,—a result at complete variance with the notions generally received. To regulate the scale of the instrument, the tenth part of the centesimal subdivision was adopted, or the distance from freezing to boiling was distinguished into a thousand degrees.

By successive improvements in its construction, the Differential Thermometer was rendered simple, precise, and elegant. But the instrument still betrayed imperfection, the limit of equilibrium or the zero of the scale visibly sinking in the course of several months. This was owing to the diminished elasticity of air in immediate contact with the liquid lodged below one of the balls, which continued to absorb oxygen, and deposit its colouring matter. But early in 1800 every source of error was removed, by adopting, as the movable fluid, concentrated sulphuric acid tinged with carmine, which remains unaltered for any length of time, though exposed to the full glare of the sun.

The precision of the Differential Thermometer now fitted it for a variety of nice inquiries. One of the most important was to ascertain the alteration of the charge of heat in air, corresponding to a change of the elasticity or volume of this fluid. When the variation was small, the allowance of two centesimal degrees for each hundredth part of the difference of density seemed to be a very near approximation. Thus, if a mass of air be condensed one fiftieth part, it will have its temperature raised one degree, or give out one degree of heat; on the contrary, a like expansion of air occasions an equal absorption of that element, or the appearance of cold. But when the difference of elasticity is considerable, some modification becomes requisite; and a very simple formula was found to connect the experimental results. Let this elasticity change from 1 to e, then the heat evolved or absorbed is expressed in centesimal degrees by $25^\circ\left(e - \frac{1}{e}\right)$ or $\frac{25^\circ}{e}\left(e^2 - 1\right)$. A similar mode of investigation determined the relative shares of heat contained in the artificial gases and in common air.

This principle elucidates the decrease of temperature in the higher strata of the atmosphere, while the formula exhibits the scale of gradation. Hence, knowing the mean temperature of the ground at any part of the globe, it is easy to compute the elasticity and corresponding elevation which would reduce that to the zero, and mark the limit of perpetual congelation. A curve is thus traced, bending at first with a gentle declivity on either side from the equator, and then descending more rapidly and turning with a contrary flexure, grazing along the surface at the pole. The application of the instrument led more immediately to the solution of another important physical problem,—to determine the proportion of humidity or of volatilized water which air is capable of holding in solution at different temperatures. A very simple law was derived,—that the quantity of moisture dissolved constantly doubles at every 15 degrees in the rise of temperature. Thus, air at the freezing point may contain the two hundredth part of its weight of moisture, but at 15° it will hold the 100th, at 30° the 50th, at 45° the 25th part; so that, if it were safe to push the progression to its extremity, the air could unite with rather more than half its weight of steam at the limit of ordinary ebullition.

Similar conclusions were derived from the waste by exhalation at different temperatures. A large hollow ball of thin metal, covered with a close coat of linen, and filled with boiling water, being suspended from the end of a fine beam, and 10 grains of water at successive intervals repeatedly sprinkled over the surface, the times of dissipation were carefully noted, and the corresponding solvent powers of air hence inferred.

The Hygrometer likewise determined the relative portions of Heat contained in water and air. It is evident, from the theory before explained, that were the heat diffused according to the densities of these fluids, each millesimal degree of moisture would equal the 6000th part of the air which held it. But adopting the capacity or measure assigned to air by Dr Crawford (then esteemed the most accurate), each hygrometric degree would correspond to the 3460th part of the weight of the solvent. Both of these proportions were found, however, to differ widely from the truth. A wet card being tied to the instrument, it was let down into the centre of a large glass globe with a narrow neck, containing 4000 cubic inches of air, and suspended through a hole in the glass cover from a fine balance; the progress of humifaction and the concomitant loss of weight were at short intervals of time nicely observed. From this comparison it resulted, that the moisture sufficient to mark an hygrometric degree is only the 20,000th part of the air with which it unites. Hence the atmospheric fluid, instead of being charged with nearly twice as much heat as water, as had been generally presumed, holds only three-tenths of that quantity. The proportion afterwards given, in some elaborate experiments of Petit and Dulong, was rather smaller, or 26 parts in 100; but the former result is simpler, and probably more exact.

The principles thus established serve at once to confirm and illustrate the ingenious Theory of Rain, which the keen sagacity of Dr James Hutton had elicited from observation about the year 1786. The commixing of two bodies of damp air that have different temperatures, must always occasion a precipitation of moisture more or less copious; for, since the solvent power augments in a geometrical progression, the loss of it which the warmer air suffers will constantly exceed what is gained by the heating of the colder portion of the damp mass.

A curious conclusion followed from those *data*: Supposing the vast canopy of air, by some sudden change of internal constitution, at once to discharge its whole watery store, this precipitate would form a sheet of scarcely five inches thick over the surface of the globe. During the course of a year, our atmosphere must therefore deposit five or even ten times all the moisture it held in solution. To explain the actual phænomena, it is hence requisite that this restless medium should change unceasingly from a state of dryness to humidity. Such alternations are effected by the system of winds, which sweep variously over the land and the ocean. But to complete Dr Hutton's Theory of Rain, it becomes necessary to have recourse to the operation of opposite humid currents of different temperatures, which bring their grazing surfaces into rapid intermixture over a given spot, where the aqueous precipitate is copiously discharged.

A further application of the Hygrometer detected the influence of rarefaction in augmenting the dryness of air. The change is rendered very perceptible, by introducing that instrument in its quiescent state under the receiver of a pneumatic machine. On working the pump, the hygrometric action which had ceased is instantly renewed, and urged constantly forward in proportion as the process of exhaustion advances. The dryness thus induced amounts to 50 degrees, every time the rarefaction is doubled. If air had the same temperature at all elevations, it would exhibit a regular gradation of dryness. But at each ascent of 2800 feet, though the air is constitutionally 7 degrees drier, it likewise becomes 5 degrees colder. This continued diminution of temperature predominates at first over the progressive arid quality of the medium, till the apparent moisture has become extreme, beyond which limit the attenuated air continues to spread drier and more pellucid. The Curve of Greatest Humidity, forming the proper range of clouds, rises about two miles above the Line of Perpetual Congelation. The pervading clearness of the upper region, without which the surface of our Earth would have been wrapped in perpetual darkness, is entirely owing to the property of rarefaction augmenting the solvent power of the air.

From the theory of the Hygrometer, it is obvious that the instrument marks the dryness of the ambient air only at the reduced temperature of the wetted ball. To find the true dryness of the atmosphere, a correction is to be applied for the superior solvent power of its actual temperature. With this view auxiliary tables are constructed, which give also the coldness of extreme humidity, or what has been termed the *Dewing Point.* But it is liable to considerable uncertainty. Placed within a metallic case, the wetted Hygrometer will gain the zero of the scale; but when covered with a glass shade, it will stand at 5 or even 10 degrees of dryness, the vitreous surface, aided by heat, abstracting the humidity from the inclosed air, and preventing it from attaining the state of saturation.

The Differential Thermometer was now directed to a more extensive and important subject of inquiry,—the mode of the propagation of heat among various bodies. Considering it as a subtile diffusible fluid, a nice investigation of the phænomena might disclose the nature of its connexion with other substances. Ascending by a regular gradation, bodies may be distinguished into solid, liquid, and gaseous. Suppose a cylinder of silver, cased in down, had the one end heated always to the same degree, the heat would advance and discharge itself from the other. If the igneous fluid were merely passive, like a current of water, the elevation of temperature and the inverse length of the cylinder would follow the square of the velocity of discharge, and not the simple ratio, as actually observed. Heat is therefore never passive, but powerfully attracted by its recipient. No portion of the cylinder can receive or deposit its heat, without simultaneously suffering a corresponding expansion or contraction. The heat is thus transferred from stage to stage, by a series of concatenated dilatations and contractions; and these alternate oscillations, which are quicker in some substances than in others, create the only impediments to the flow, that would otherwise be almost instantaneous. The elasticity of heat must be prodigious, since its weight eludes all examination. Considering its extreme tenuity, the expansive energy which it displays can only be assimilated to the mutual repulsion of the particles of Light. Every appearance, indeed, seems to indicate that Heat is merely Light under a latent and combined form.[1]

In the case of liquid substances, the communication of Heat is more complicated. Suppose Heat were applied to the upper surface of a vessel containing water, its influence would gradually descend, precisely in the same manner as if the whole mass had been consolidated; for the warmer and dilated portions, retaining their several positions, would continue to float in successive strata graduating downwards. But if the bottom of the vessel were subjected to the same process of heating, the water, as fast as it grew warmer and specifically lighter, would rise and diffuse its acquired heat. The communication of this influence would hence become rapid, and spread itself in horizontal strata. But every renewal of the sentient surface must likewise promote the dispersion of heat through a fluid mass. Such is the expenditure of heat from a hot ball plunged in the current; but in cold still water, the heat being dispersed by two distinct processes, the ball at first cools in a much faster ratio than the difference of temperature, but ultimately approximates to that ratio. The loss of heat is, however, the same, whatever be the nature of the surface encircled by the water, whether of metal or glass, or cased in linen. Water moving in a current at the rate of only a mile an hour, will abstract four times as much heat as if it had remained stagnant.

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[1] "The only fluid we know, combining enormous elasticity with extreme diffusion, is Light itself, which when embodied constitutes *Elemental Heat*, or *Fire*. It is elicited from every substance by percussion or compression, by electrical agency or chemical affinity. With every species of light our vision is equally perfect, and consequently the luminous particles must

But when a hot ball is suspended in air, another element of dispersion now comes into play. The air in contact becoming heated and rarefied, ascends continually and scatters the heat. But another portion of heat is discharged from the cooling surface by a rapid rectilineal projection. This emanation is best observed in substituting a cubical vessel with different sides of glass, or of polished or papered metal. It is most powerful in front, diminishing laterally as the cosine of the angle of declination. From a surface of linen the propulsion of heat is ten times, and from that of glass eight times greater, than from a bright polished metallic surface. This peculiar dissemination of heat, which from a glass ball amounts to nearly half of the whole discharge, is not performed by the actual flow of the heated air, though it requires the agency of a gaseous medium. The discharge can be collected at any distance by a metallic reflector, and thrown concentrated on the naked ball of the Differential Thermometer. But the intervention of a large sheet of tin-foil obstructs the whole effect, while a very fine screen of gauze, which would stop the passage of streamlets of hot air, scarcely impedes the operation. It is impossible, therefore, to resist the conclusion, that what has been vaguely termed the *radiation of heat*, consists in a certain propulsive effort or internal tremor, excited in the gaseous medium, analogous to the undulatory propagation of sound. The air can be shown to have a closer contact with glass than with metal, and hence the former surface exerts a superior energy of pulsation. The interval in the case of glass appears to be about the 500th part of an inch. A metallic ball, coated with the finest gold-beater's skin, of only the 3000th part of an inch in thickness, will have its pulsatory energy augmented from 1 to 6; and by the addition of other films, this dispersive power will successively rise to 10.

In air rarefied 200 times, the abductive power from the glass balls is reduced from 6 to 1, while the peculiar discharge of heat at the naked surface is depressed from 7 to 5, and that at the gilt surface from 1 to $\frac{3}{4}$; the naked ball emitting now $6\frac{1}{2}$ parts of heat, and the gilt one only $2\frac{1}{4}$. The effects are changed in a different gaseous medium. Thus, the same balls, with a vitreous and metallic surface, would discharge 31 and 25 parts of heat if immersed in hydrogen, both of them losing 24 parts by the powerful abduction of that gas. But were the medium rarefied about 200 times, the quantities of heat emitted from the naked and the gilt ball would be reduced to 13 and $8\frac{3}{4}$.

The principle thus unfolded applies with mathematical precision, and illumines an extensive train of phænomena. It likewise suggests

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in all cases dart forward with the same celerity, or travel at the rate of about 200,000 miles in a second. But since atmospheric air is projected into a vacuum with the velocity of only a quarter of a mile each second, the motion of Light is thus 800,000 times more rapid. Wherefore the propulsive force of Light compared with that of Air is expressed by the square of this number, or 640 billions." In the state of combination with Air, since it must have the same elasticity as that fluid, Light must hence be 544,000,000,000,000,000 times rarer than water. See *Elements of Natural Philosophy*, vol. i. p. 452.

various improvements in the practical arts, and in general economy. One of the finest modifications of the Differential Thermometer converts it into the *Pyroscope*, by merely gilding richly one of its balls. By this alteration it is fitted to measure nicely the hot or cold pulses, and hence to determine the relative powers of fuel, and the efficacy of variously constructed chimneys. The access of heat is almost entirely repelled from the gilt ball, while its accumulation on the naked ball is regulated by its subsequent tendency to disperse through the ambient air. The action of wind must evidently lower the effect, insomuch that a current at the rate of only eight miles an hour will reduce it to the half. To fit the Pyroscope for observations out of doors, it became therefore necessary to shelter it from the sweep of aerial streams. This protection was obtained by adopting the pendant form of the Differential Thermometer, inclosing the lower ball within a larger one of silver, and inserting the upper one in the focus of an oblong spheroidal cup, cut over at the remoter focus. It was thus converted into an *Æthrioscope*, which indicates the cold pulses darted at all times from the higher strata of a clear atmosphere, but more copious in summer than in winter, and stronger during the day than the night. The information afforded by that delicate instrument completely elucidates the successive steps towards a correct Theory of the formation of Dew, by Musschenbroeck, Dufay, Six, Wilson, Bernard Prevost, and finally the late ingenious Dr Wells.

In analyzing the process of evaporation, the cold induced on the humid surface was attributed solely to the quickened transfer of the contiguous portions of the ambient medium. "But the conterminous air must besides communicate heat to the water by pulsation; and consequently the balance of temperature would be liable to incidental variations, if moisture, with its embodied heat, were not likewise abstracted by some corresponding process. And such is the harmonious adaptation of these elements. The discharge of vapour appears to be subject precisely to the same conditions as the emission of heat, and in both cases the proximity of a vitreous or a metallic surface produces effects which are entirely similar." This beautiful property was established by decisive experiments, which render the theory of the Hygrometer absolutely complete. But the performance of that instrument received further confirmation and clear elucidation from the contrast of the *Atmometer*, which indicates with great accuracy the quantity of exhalation from a given surface in a certain time.

A train of observations performed by this Hygrometer in 1810 led to the method of producing artificial congelation on a large scale. Having ascertained the increased power of aqueous solution which air acquires as it grows thinner, it was next suggested to combine the action of a vigorous absorbent with the transient dryness created within a receiver by rarefaction. "On introducing a broad surface of concentrated sulphuric acid, this substance was found to superadd its peculiar attraction for moisture to the ordinary effects resulting from the progress of exhaustion; and, what was still more important, it continued to support, with scarcely diminished energy, the dryness thus created. The attenuated air was not suffered, as before, to grow charged with humidity; but each portion of this medium, as fast as it became saturated by touching the evaporating porous dish, transported its vapours to the acid, and was thence sent back denuded of the load, and fitted again to renew its attack. By this perpetual circulation, therefore, between the exhaling and the absorbing surface, the diffuse residuum of air is maintained constantly at the same state of dryness. Heat is hence abstracted in proportion to this invigorated evaporation. If air be rarefied only 50 times, a depression of temperature will be produced, amounting to 80 or even 100 degrees of Fahrenheit's scale." It is hence easy in the hottest weather, and in every climate, to freeze a body of water, and keep it in a congealed state, till it gradually wastes away by a continual but invisible process of evaporation. On a large scale the operation would be conducted the most profitably; insomuch that a proper system of air-pumps, put in motion by a steam-engine of only six horse power, might in the climate of London produce at the rate of a ton of pure ice every day. Other absorbent substances besides sulphuric acid could be employed, though not so advantageously; such as pounded trap-rock slightly roasted, parched oatmeal, and dry sole-leather. When water is excluded, the dryness created within the exhausted receiver may be turned to different useful purposes. This process is now commonly employed, especially on the Continent, in the nicer chemical analyses. It can likewise be directed to delicate preparations, which the action of heat might derange.

The application of these various refined instruments forms a sort of æra in the progress of philosophical apparatus, and has contributed to introduce into physico-chemical researches a precision and delicacy unattempted before. What seems wanted at present to complete our knowledge of Heat, is not the vague repetition of experiments already carefully performed, but a nice investigation of several unexplored properties, directed with scrupulous accuracy and on a large scale.

The systematic application of Heat has, during the eighteenth century, produced a complete revolution in the mechanical arts. Air, steam, and water are often employed as *carriers* of Heat, but with very different energies. These fluids being all raised to the pitch of boiling water, while a current of air will transmit only one degree of Heat, a like current of steam will communicate 12 degrees; but a stream of water with the same celerity and transverse section will, from its density and high charge, communicate no less than 2800 degrees of Heat.

The alternate expansion and contraction of fluids by heating and cooling evolves prodigious powers. It may be shown that, with the same expense of Heat, air itself treated in this way exerts about three times as much force as what is obtained from the successive formation and condensation of steam. If such reciprocal changes were impressed on air as rapidly as on steam, the application of that medium would soon supersede the most efficient of all engines.

The expansive force of steam was finely displayed by the *Æolipile*, an instrument constructed in the Alexandrian School. After the revival of science, it had been employed to set in motion a variety of toys; but no efficient application of steam was achieved in the seventeenth century. It seems idle to examine the pretensions of such projectors as the Marquis of Worcester or Sir Samuel Morland, who caught at any shadowy schemes, to retrieve their ruined fortunes.

The person who first considered the properties of steam philosophically was Papin, a physician born at Blois, who visited England in 1680, and became curator to the Royal Society. The *Digestor*, which he constructed next year, exemplified the enormous elastic force that steam acquires when heated and confined. As a source of power he proposed atmospheric pressure, by forming a vacuum either by the inflammation of gun-powder or the condensation of steam. Precluded by the revocation of the Edict of Nantes from returning to France, he accepted in 1687 an invitation from the Prince of Hesse to a chair in the University of Marburg. There he extended his plans, but found no helps to carry them into execution. The superior skill of English artists transferred the palm of invention. Newcomen, a blacksmith, and Cawley, a glazier, natives of Dartmouth in Devonshire, by their united studies and labours, produced the Atmospheric or Fire Engine in 1705; but, to prevent opposition, they associated in their patent a naval officer, Savery, who had a few years before contrived a very imperfect machine, which acted however by alternate expansion and condensation. Accident suggested the injection of cold water within the steam-vessel, instead of external affusion. Beighton simplified the mode of opening and shutting the valves, and improved the whole system of machinery; and in the course of half a century, the Fire Engine was adopted for raising water in all the coal-mines.

At this epoch the genius of Watt, guided by sound judgment and urged by unremitting application, effected in less than forty years a complete change in the powers of mechanism. His steady purpose was to reform the principles of the steam-engine, and reduce its composition to mathematical precision. He began with performing the condensation in a vessel distinct from the working cylinder; and he next excluded atmospheric pressure, and merely employed the alternate action of expanding and contracting steam. But to pursue his career of invention might demand a separate disquisition.

7. ASTRONOMY.

THE varying spectacle of the heavenly bodies has attracted the curiosity of mankind since the very dawn of civilisation. In the genial regions of the East, where societies were first collected, the rural inhabitants, accustomed to enjoy the freshness of the nights in the open fields, contemplated with wonder the sparkling radiance of a pure canopy, remarked the groups of stars, and learned by degrees to trace their successive changes, and to connect these with the periodic motions of the great luminaries. The rudeness of such early observations was compensated by the number of the included revolutions. The occasion of an eclipse or an occultation served, by disclosing the coincidence of different periods, to rectify the elements of the planetary movements. Astronomy has grown up by a slow accumulation of facts, continued through a long tract of ages. It had acquired considerable accuracy in practice, before it received any tolerable lights from theory. But the art of observing has in modern times acquired amazing precision, from the very improved construction of instruments, and the extended methods of calculation. The register of a single year may now furnish more complete data than the aggregate observations of a whole century in remote ages.

The great cultivators of astronomy are divided into two classes,—accurate and inventive observers,—and profound and original theorists. Of those illustrious men who, in the lapse of three thousand years, have devoted their labours to so noble a purpose, we may distinguish a few that have stood pre-eminently above their compeers;—as observers, Hipparchus, Ptolemy, Tycho Brahé, Hevelius, Cassini, Flamsteed, La Caille, Bradley, Maskelyne, and Piazzi;—and as theorists, Copernicus, Kepler, Newton, and after some interval Clairaut, D'Alembert, and Euler, and in our own times the associated names of Lagrange and Laplace. Astronomy is not only the sublimest of all the sciences, but has at last reached the highest pitch of perfection, and constitutes by far the grandest monument of human assiduity and genius.

The progress which Astronomy has made since the decease of Newton may be referred to five separate heads; 1. The investigation of the figure of the earth, and of the other planets; 2. The determination of the anomalies of the moon's motions, and their application to the finding of the longitude at sea; 3. The analysis of the prolonged effects resulting from the mutual disturbing influence of the planets; 4. The improved theory and observation of comets; and, 5. The telescopic discoveries of new planets, and the vast expansion of the catalogue of stars.

1. *Investigation of the Figure of the Earth and of the other Planets.*—It was easy, by combining the rotation with the length of the radius of the Earth, to compute that every body at the equator must lose the 289th part of its weight, from the action of centrifugal force, which, being proportional to the distance from the centre, will exert only half such influence over the whole mass; and therefore supposing this to be homogeneous, and assuming with Huygens that gravitation is all directed to a central point, and equal at every distance, it thence followed that our planet is an oblate spheroid, of which the Equatorial is to the Polar diameter as 578 to 577. But Newton had already explored the question with consummate penetration; and, setting out from the great principle of an attraction subsisting among *all* the particles of matter, had, on the hypothesis of homogeneous fluidity, shown that the equatorial column has its pressure at the centre diminished by the elliptical defect of the sphere, while the action of the perpendicular column is augmented from the opposite cause; and thus a greater inequality than the mere influence of centrifugal force becomes requisite to produce equilibrium, assigning 230 to 229 as the ratio of the diameter to the axis. This solution, however, was merely tentative, the imperfection of the calculus being compensated by a refined sagacity, which noted only the leading steps.

The explication of the System of the World from the Theory of Attraction, embraced with indolent acquiescence by the countrymen of Newton, was either opposed or viewed merely as an ingenious speculation by most of the philosophers on the Continent.[1] But a controversy now arose, which brought the accuracy of these principles to the test of observation, and secured their final triumph. It is evident that the length of a degree of the meridian must be proportional to the distance of the centre of mutual concurrence of the plummets from its extremities, or to the radius of external curvature. In the case of an oblate spheroid, therefore, those degrees would regularly enlarge from the equator to the pole. But the Trigonometrical Mensuration of France, begun by Picard in 1675, and completed in 1716 by Cassini, forming the most extensive survey yet attempted, was found leading to an opposite conclusion in the meridional arc, the degrees on the north of Paris, instead of lengthening, appearing to contract about a 430th part below those on the south, which would indicate an oblong figure, having its perpendicular diameters as 96 to 95. This perplexing result served to keep alive for some time longer the controversy on the Continent between the followers of Descartes and the growing partisans of the Newtonian Philosophy. In the meanwhile, a clock made by the famous Graham, and carried out to Jamaica in 1732 by Colin Campbell, was ascertained by astronomical observations at Black-river, in the latitude of 18°, allowing for the influence of heat on the pendulum, to go 1′ 58″ slower every day than in London. This quantity of variation Bradley found to exceed what would suit the figure calculated by Newton, and he was therefore disposed to attribute the effects to some diminution of density in the equatorial regions. James Stirling comprised the attractions of homogeneous spheroids under two beautiful theorems, which were published, though without demonstrations, in the Philosophical Transactions for 1735. About the same time Bouguer noticed some restrictions essential to the rigorous solution of the problem; but now Maclaurin took a most commanding view of the subject, and produced, first in his famous Dissertation on the Tides, and again more fully in his Treatise of Fluxions, printed in 1742, a geometrical investigation, distinguished by its originality, clearness, and superior elegance. This illustrious mathematician established, from the law of gravitation, the stability of a fluid spheroid revolving about its axis in a certain time, proved that every point within the mass would be pressed equally on all sides, and showed that even the superadded attractions of the sun and moon could not disturb the internal equilibrium of our Earth. The conclusions applied likewise to the other planets, and embraced the theory of the tides. But his profound investigation likewise disclosed several general theorems, which have greatly simplified and extended the science of Hydrodynamics.

The most refined theory, thus confirming the Newtonian figure of the Earth, again recalled the attention of philosophers to the actual survey of its surface. The French triangulation being resumed in 1740, an error was detected in the measurement of the base, and another not less considerable in the observation of the meridional arc; but to rectify the various details required the labour of several years, nor did the work terminate before 1754. In the extent of above eight degrees, their lengths appeared regularly to increase, from Perpignan to Dunkirk, by about the 1730th part; marking evidently the oblateness of the spheroid.

But it was most desirable to resolve the question on a larger scale; and the Academy of Paris, urged in 1733 by Condamine to send a party to measure a degree under the Equator, adopted his project with zeal, and fortunately obtained the sanction of government. After all the preparations were made, the Academicians, Condamine, Bouguer, and Godin, in May 1735 sailed from Rochelle to Peru, where they joined Juan and Ulloa, two naval officers deputed by the king of Spain. The whole company assembled in the month of June in the following year at Quito, almost under the Equator, and arranged their plan of operations. They chose a valley of the Cordilleras running above 200 miles southwards from that city, and inclosed on both sides by the loftiest ranges of the Andes. Divided into two troops, they carried a series of triangles along the flanks and summits of those stupendous mountains covered with eternal snows, and connected the reticulation with the base measured below. In pursuing their laborious task, the observers had to encounter the greatest difficulties, and to suffer privations of every kind, owing to the severity of the climate and the total want of accommodation, joined to the continual impediments occasioned by the superstition of the natives and the pilfering habits of the Indians. But resolution and perseverance at length overcame the multiplied obstacles, though no fewer than eight years were consumed in completing with elaborate care and accuracy the different operations undertaken. Condamine was a man of an ardent and active mind, and persuasive address; Godin, an excellent observer; but Bouguer combined the character of a deep and original thinker, with the talent of invention, unwearied application, and an extended acquaintance in the various pursuits of philosophy and science. The Academicians were ably assisted by their Spanish associates, though each performed separately his own calculations. It was reserved, however, for Bouguer to give the complete narrative of all the various operations, in his *Treatise on the Figure of the Earth*, not published till 1749, but one of the most valuable scientific works that has ever appeared. Besides amply discussing the principal question, it investigated incidentally the effects of local attraction on the plummet, the length of the pendulum, the theory of refractions, the rules of barometrical measurements, the limits of perpetual congelation, the intensity of the solar rays at different elevations, and the celerity of sound as affected by heat. He concluded that the Earth is not only an oblate spheroid, but so considerably flattened as to have its equatorial diameter to its axis in the ratio of 179 to 178; and he thence inferred that the central parts must be four or five times denser than the superficial crust.

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[1] In a letter written from Basle on the 22d November 1729 by Nicholas Bernoulli, to his friend James Stirling at London, with whom he had become acquainted several years before, when the former was professor at Padua, and the latter a teacher of Mathematics in Venice, he confesses, with regard to Machin's attempt to illustrate the Lunar Theory, that he had not yet taken the trouble to read the third book of the *Principia*. *Pauca quidem in eo intelligo, quia nullam adhuc operam collocavi in lectione tertii libri Principiorum D. Newtoni.* Stirling, in his answer, dated in September 1730, frankly remarks, that "it is somewhat strange, that though the *Principles* have been published above 40 years, nobody has read further than the two first books, although they be barely speculations, and were written for no other reason but that the third might be understood." (From a collection of Stirling's papers in the possession of Mr Irving, one of the Judges of the Court of Session, under the title of Lord Newton.)

In the mean time, it being foreseen that the mensuration of a degree in Peru would be necessarily retarded, the celebrated Maupertuis, a person of agreeable attainments, though not very profound in science, prevailed with the French minister Maurepas to dispatch another company, which he reluctantly consented to lead, for a similar purpose to the Arctic Circle. His associates were Monnier, Camus, Outhier, and Clairaut, already distinguished by the precocity of his fine mathematical genius. They arrived at Stockholm in June 1736, and were joined by Celsius, the professor of astronomy at Upsal, who had brought from London Graham's zenith sector and transit instruments. Having settled their general plan, they proceeded to the bottom of the Gulf of Bothnia, and selected Tornea for the principal station. From that small capital they stretched a chain of triangles along the wooded heights to the top of Kittis, a distance however not exceeding 60 miles. Working with great spirit and activity, and having no difficulties to encounter but the severity of the climate, they observed the angles from the several stations during the remainder of the summer, determined the celestial arc in autumn, and measured the base along the frozen surface of the river Muonio in the early part of winter. The length of a degree of latitude at the Arctic Circle was found to be 57,419 toises, or 349 toises longer than the corresponding measure at Paris, which gave the ratio of 178 to 177 for that of the Equatorial and Polar diameters, almost the same as the result of the more extensive operations afterwards in Peru. Maupertuis, having with such expedition ascertained the oblateness of the Earth, and assigned a depression still greater than had been computed by Newton, returned triumphant to Paris in the spring of 1737. But this arctic triangulation, betraying evident marks of haste, became suspected afterwards of inaccuracy; and, at the suggestion of Melanderhjelm, the Swedish academy, about the beginning of the present century, sent Svanberg, with proper assistants, to resume the operations, who not only rectified the former observations, but carried the mensuration about 40 miles farther north.

It was then determined that the length of a degree in Lapland is only 57,209 toises, which, compared with Cassini's corrected measure in France, reduces the oblateness to the 290th part of the Earth's axis. But a more accurate result is obtained from the comparison of the distant observations made under the Equator and at the Arctic Circle, the perpendicular diameters of the terrestrial spheroid being in the ratio of 302 to 301. Still greater nicety has been attempted by Littrow, who, on re-computing the degree in Lapland, reduced it to 57,168 toises, which gives an oblateness of only $\frac{1}{312}$.

Other determinations of a degree of latitude have been made at different parts of the Earth's surface, the most remarkable of which may be noticed. La Caille, one of the best observers, and the most accurate and laborious of astronomers, rectified the French triangulation during the years 1739 and 1740; nor did the extreme severity of that memorable winter prevent his carrying forward these operations over the lofty mountains of Auvergne. He proved decidedly that the degrees of the meridian regularly increase from the south to the north of France. Some years afterwards he went to the Cape of Good Hope, chiefly for the purpose of framing a catalogue of the stars of the Southern Constellations; but his ardour and extreme activity enabled him to accumulate other valuable celestial observations. Having performed the task he had proposed, and the ship not arriving to carry him home, La Caille was tempted to employ the time thus afforded in measuring by his single exertions a degree of latitude. This he found, on the parallel of 34°, to be 57,037 toises, and therefore of the same length with a degree as far north as 49° in France; which seems to indicate not only a flatter outline, but a difference of internal constitution in the southern hemisphere. The accuracy of the measurement itself, however, has been strongly suspected.

In 1750 and the two following years, Boscovich and his associate La Maire measured an arc of two degrees in the Papal States, and fixed the length on the parallel of 43° at 56,979. Beccaria traced a single degree in Piedmont, and found the opposite attractions of the lofty sides of the Alps had such influence in deflecting the plummet, as to render the northern half of the measure a 69th part longer than the southern.

After a pause of near forty years, the mensuration of the Earth was revived with increasing ardour and on a grander scale. The object first contemplated was merely to settle the difference of longitude between the observatories of Greenwich and Paris, by connecting them with a series of triangles. General Roy directed the English survey in 1784, while similar operations were conducted by Cassini in France. The Revolution soon followed, and prepared the public mind for the reception of every bold project. It was now proposed to adopt a universal and permanent system of weights and measures drawn from nature, the unit of linear extent being the thousandth part of a centesimal minute, or the ten millionth part of the quadrantal arc from the Pole to the Equator. To obtain this standard, it had been resolved to carry a chain of triangles over the whole extent, from Dunkirk to Barcelona; which was performed during the most eventful period of general excitement and commotion, by the profound sagacity, perseverance, and undaunted zeal of Delambre,[1] joined to

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[1] Born at Amiens on the 19th September 1749. Being designed for the church, he studied the ancient languages in the *Gymnasium* of his native city, first under the Jesuits, and afterwards under the tuition of the poet Delille, to whom he became warmly attached. At a ripe age, he was invited to the study of astronomy by Lalande, and soon adopted as his favourite pupil. In 1785 he began the vast series of his scientific labours, which occupied the rest of a long life. Without aiming at originality, Delambre produced very complete and valuable works, pursued his immense calculations with scrupulous nicety and incessant application, and distinguished himself as a most accurate, skilful, and indefatigable observer. He sought precision merely, and was rather indifferent about the elegance of his *formulæ* or composition. Yet he was an excellent Greek scholar, well acquainted with the principal modern languages, and indeed a man of general erudition. Of an amiable disposition, with fixed principles of integrity joined to simple habits, he passed through all the storms of the Revolution with a blameless character. He obtained his full share of the honours and distinction which France so liberally bestows on those eminent in science, and died universally regretted, on the 19th of August 1822.

Mechain.[1] After completing this operation, they measured a base of seven miles in length near Paris, and another of verification, somewhat shorter, on the road from Perpignan to Narbonne. The register of all the observations was in the spring of 1799 submitted to a sort of congress of scientific men assembled in the French capital, who having examined and repeated the various calculations, and compared the celestial arc with the mensuration in Peru, adopted the 334th for the oblateness of the earth, and determined the distance of the pole from the equator to be 5,130,740 toises.

Mechain, anxious however to extend the meridian as far as the Balearic Isles, again repaired to Spain, and conducted a series of triangles over the savage heights from Barcelona to Tortosa, when, exhausted by incessant fatigues, he caught an epidemic fever, which proved fatal in September 1805. The operations were continued by his young but very able successors, Biot and Arago, who terminated the meridional arc at the isle of Formentera in 1807. This extension of the chain scarcely altered in the slightest manner the former conclusion.

The English survey, being designed merely for the construction of an accurate set of maps, suffered some interruption by the death of General Roy, but was resumed with spirit in 1793, under the skilful direction of Colonel Mudge, who carried the triangulation as far as the north of Scotland; and since his decease in 1820, the work has been transferred to Ireland by his persevering assistant and successor Colonel Colby. The method of observing is now improved, and all the refinements of modern art have been exhausted in the mensuration of a new base.

Those operations have no doubt proceeded very slowly, and yet the results of the first series were perplexing, the three degrees measured from Dunnose to Clifton successively contracting instead of lengthening, and therefore indicating, like the earlier observations of Cassini, an oblong figure of the Earth. The whole arc agrees exactly with the last triangulation of France, in giving an oblateness of only the 334th part; but whether the intermediate discrepancies should be imputed to an error of azimuth, or to the probable derangement from local attraction, still remains undecided.

In 1802 and 1803 Colonel Lambton measured a degree of the meridian in the East Indies, and found, at the latitudes of 9° 35′, 12° 3′, and 16° 35′, the lengths to rise successively to 60,477, 60,490, and 60,512 fathoms. Hence Delambre deduced the oblateness of the terrestrial spheroid to be the 206th part. But Rodriguez, an able Spanish mathematician, who had already criticised the observations of Mudge, detected various mistakes in Lambton's calculations, which being rectified, reduced the depression of the Earth to the 320th part.

Since the spheroidal figure of our planet is evidently subject to great irregularities, we are led to inquire, whether it be a solid of revolution and have true circles for its parallels of latitude. Cassini and Maraldi seem to have been the first to solve this interesting question. They found, in 1734 and 1735, a degree of longitude at Paris and at Strasburg to be 36,676 and 37,745 toises, and therefore considerably less than what belongs to a perfect sphere. But the most accurate observation of this kind was made by La Caille in 1740, from the top of a hill near Aix, to a signal on a high tower above the Rhone, about 96 miles remote, where he caused ten pounds of gunpowder to be fired, and found by the instantaneous blaze the difference of time between the two meridians, and then measured trigonometrically along the plain of Arles the intermediate distance, which gave 41,358 toises for a degree of longitude, or 260 toises less than a globular form would require. Lambton estimated the degree of longitude on the parallel of 12° 32′ to be 61,061 fathoms, or 57,294 toises; but his observations and calculations seem not entitled to much confidence. The latest and most accurate measurement of a perpendicular to the meridian was performed in 1823, near Geneva, by Colonel Brousseaud, of the French engineers, in connexion with the late ingenious Professor Pictet, while the skilful astronomers Plana and Carlini completed a similar operation on the plains of Italy as far as Padua. The first, being compared with the arc from Greenwich to Formentera, gave a 271st part for the oblateness of the Earth; but, when conjoined with the Italian prolongation, it reduced the quantity of depression to a 292d part of the equatorial diameter. It must be confessed, however, that the accuracy of these conclusions has been contested by some of the ablest calculators.

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[1] Born at Laon 16th August 1744, the son of an unprosperous architect, who could hardly educate him in the same profession. The youth supported himself, and even aided his father, by teaching mathematics, and made such proficiency in astronomy as to attract the notice of Lalande, by whose warm and active patronage he soon obtained the office of hydrographer to the Marine at Versailles. Though he had not the talent of invention, he became an expert, patient, and correct calculator. He was, besides, a very nice and accurate observer, and applied himself particularly to the search of comets, and the computation of their orbits. In 1784 he was joined to the commission for adjusting the difference of longitude between the observatories of Paris and Greenwich; and when the Constituent Assembly had resolved to adopt a grand metrical system founded on the length of the meridional arc, he was appointed to measure the southern portion of it from Barcelona to Rodez. He conducted his operations with great celerity and success; but, inspecting a new engine constructed by a friend at Barcelona, he met with a dreadful accident, which had well nigh proved fatal. After a slow convalescence he resumed his labours; but every thing now combined to dishearten him,—the war with Spain, the ravages of the yellow fever, and the news of the reign of terror in France. After moderation had revived, Mechain with much reluctance was prevailed on to come to Paris; but strongly pressed the expediency of extending the measurement two degrees farther into Spain, and insisted on carrying on that work himself. This pertinacity was not explained till after his death, when it appeared that he had concealed a discrepancy occurring in the rectification of his observations, which, without acknowledging the error, he no doubt hoped to remove by subsequent operations. After experiencing many difficulties, he vigorously renewed his labours in Valencia; but his mind was depressed by anxiety for his reputation, and alarms at the spread of contagious disease. This mental prostration favoured its attack, and he expired of yellow fever in his retreat at Castellon de la Plana, on the 20th September 1805.

From a skilful combination of the five principal measurements, in Peru, India, France, England, and Lapland, Mr Ivory has, by the method of the *least squares*, deduced $\frac{1}{309}$ for the oblateness of the Earth, and shown that the corresponding elliptical meridian agrees with the best observations. The result would have been still more satisfactory, had the English survey comprised the whole extent of the island. But a very small portion of the arc is computed, and the fruits of twenty years' expensive operations are not yet communicated to the public. Meanwhile, other surveys, conducted after the most scientific manner, are now far advanced; in Lower Saxony by Gauss, in Holstein by Schumacher, in Swabia by Bohnenberger, and in Russia and Finland by Struve. These continental observations must throw much light on the form and constitution of our planet.

Local attraction may deflect the plummet from its vertical position, but it can have little effect on its general gravitation. The vibration of a pendulum, therefore, promises a readier and surer method of discovering the figure of the Earth. The difficulty is to ascertain the length with extreme precision, or the distance between the point of suspension and the centre of oscillation. The pendulum constructed by Borda seemed to require little correction. It consisted of a slender iron wire about 13 feet long, terminated by a small cap of copper, to which was nicely fitted a ball of platinum about an inch and half in diameter. The vibrations were performed in two seconds and continued for twelve hours, the number being reckoned from the distant coincidences with the pendulum of an astronomical clock. Mathieu has computed, from six observations made with this instrument along the meridian from Dunkirk to Formentera, the depression of the terrestrial spheroid to be $\frac{1}{298{\cdot}2}$. But from a general comparison of all the various measures over the surface of the Earth, Laplace reckoned this quantity only $\frac{1}{335{\cdot}78}$. It has been alleged, indeed, that the illustrious author had committed a mistake in the taking out of a logarithm, which being corrected would give $\frac{1}{319}$.

The *Convertible Pendulum* constructed by Captain Kater, on the beautiful principle first demonstrated by Huygens, that the point of suspension and the centre of oscillation are interchangeable, seemed to promise greater accuracy, and was proposed by the inventor as furnishing an invariable standard of linear measure. So sanguine were his expectations, indeed, that he believed it could not occasion an error of the 400,000th part of the whole. But the observations which he made with this pendulum, at different points in an arc of ten degrees extending to Shetland, display no such harmony, for the resulting oblateness of the Earth varies from the extremes, between $\frac{1}{397\cdot5}$ and $\frac{1}{229\cdot6}$. It has been customary to attribute the discrepancies to the influence of local attraction, but they are frequently too considerable for the most exaggerated hypothesis to explain, and must be referred either to the inaccuracy of the observer or to the imperfection of the instrument employed. Calculators, in their endeavours to harmonize such observations, can seldom proceed dispassionately; they are apt to modify some of the data, and arbitrarily to reject others as anomalous or liable to suspicion. Parry's experiments with the convertible pendulum at London and Melville Island gave an oblateness of $\frac{1}{312\cdot6}$. The numerous observations made by Freycinct and Duperrey, in their voyages of discovery, indicated, for both the northern and southern hemispheres, a depression between $\frac{1}{280}$ and $\frac{1}{282}$. Captain Sabine concluded, from his own combined observations, that the quantity is $\frac{1}{288\cdot4}$. But Mr Ivory, whose decision is entitled to the greatest confidence, has, from a critical examination of those data, concluded the ellipticity to be $\frac{1}{300}$; and found the same figure to agree both with the measures along the meridian and those perpendicular to it. To arrive at so satisfactory a result, however, it was necessary to exclude nearly one-sixth of all the observations, those made near the equator being the most discordant. Such aberrations leave considerable distrust, which is not removed by inspecting the later observations. But it were idle to affect extreme precision, where the discrepancy amounts sometimes to a six thousandth part. The convertible pendulum appears liable to different sources of error, and though it may furnish an approximation to the determination of the terrestrial spheroid, it can hardly be expected to reach the accuracy and certainty requisite for a metrical standard.

We may now revert to the analytical investigation of the figure of the Earth. Clairaut had given the elements of the solution previous to his setting out on the expedition to the Polar Circle. But after his return from that memorable achievement, he resumed the disquisition; and adopting the geometrical discoveries of Maclaurin, he produced the completest analysis of the problem, in his very ingenious work which came out in 1743. He determined the equilibrium of a revolving spheroid, when composed of concentric layers of different densities, assuming the deviation from the spherical figure to be very small. Clairaut showed that the particles of the same density must always range in distinct strata, to which the resulting force that urges them is perpendicular; and found the general equations, simplified afterwards by Euler, for assigning the stability of the fluid mass. But it was not until 1784 that Legendre gave a direct analytical solution of the problem, in the case of a homogeneous spheroid approaching nearly to a sphere, which required the single condition that gravity should act perpendicularly at the surface. Laplace afterwards simplified and completed this investigation, by extending it to elliptical strata of different densities. The solution, however, was not rigorous, and merely exhibited an approximation, by leaving out the cubes and higher powers of the series. The numerical results yet vacillate between the proportions announced by Huygens and Newton. It is indeed remarkable, that a subject which has exercised the efforts of sublime genius, should have yet derived so little real elucidation from the stores of the higher calculus. The theorems of Maclaurin still far transcend the most elaborate displays of analytical research. But his illustrious countryman Ivory, undismayed by such formidable difficulties, has lately revived the discussion, and, examining more narrowly the physical conditions of the problem, and thus restricting the differential equations, he has with felicitous address succeeded in conducting his analytical procedure to a definite result. Britain has therefore the honour both of originating the discovery of the true figure of the Earth, and of completing its demonstration.

But the Earth's oblate shape is likewise deducible from certain small mutations in the orbit of the moon. The attraction exerted by our satellite on the protuberant matter at the Equator occasions the Nutation of the terrestrial axis; and this action being reciprocal, the moon suffers a corresponding alteration both in latitude and longitude. Such is the wonderful precision attained in astronomical observations, that Burg, one of the most expert calculators in our day, computed at the request of Laplace, from very numerous data, the ellipticity of the Earth to be respectively $\frac{1}{304 \cdot 6}$ and $\frac{1}{305}$. The motions of the lunar nodes and perigee have been shown by the same profound philosopher to indicate a similar conclusion. The form of the Earth is hence flatter than that of a homogeneous spheroid; and this difference appears to arise from the increasing density of the internal mass caused by superincumbent pressure. A like character belongs to Jupiter, the largest planet in our system; for his axes, which, from the combined action of gravity and centrifugal force, should have the ratio of 41 to 36, are observed to be only as 14 to 13, or 41 to 38, thus evincing the great compression of the internal mass.

The discussions relating to the figure of the Earth led to an examination of the Theory of the Tides, the great outlines of which had been likewise traced by Newton from the Law of Gravitation. The Academy of Sciences at Paris selected the complete investigation of this difficult subject for the prize offered in 1740; and never did three more illustrious competitors contend for the honour of an award, which was shared among Maclaurin, Euler, and Daniel Bernoulli. The dissertation of our countryman, as already observed, was pre-eminently distinguished by the new and beautiful propositions which it contained. Supposing the Earth were at rest and covered with a shell of water, any remote body, attracting the anterior surface with greater force than the lateral mass, and this again with greater force than the posterior surface, would evidently cause the fluid to rise on the opposite sides and form a prolate spheroid, having its longer axis directed to the disturbing agent. But this influence was proved by Newton to be inversely as the cube of the distance. Though the sun has above twenty million times more matter than the moon, yet being four hundred times more remote, he therefore exerts three times less influence in raising the tides. While the ocean swells out both under and opposite to the sun, it turns another trebly more protuberant spheroid towards the moon. These elevations, differently combined, produce the variable heaving of the waters which constitutes the general tide. The conditions of equilibrium are easily determined; but it is a most arduous research to distinguish the several effects of the rotation of the earth and the revolution of the moon, in retarding and modifying the oscillations of the irregular aqueous expanse. Such was the problem which so long exercised the genius and penetration of Laplace. He began the consideration of this intricate subject in 1774, and resumed his investigation repeatedly afterwards. Having obtained a general expression for the oscillations of the ocean, he distinguished these into three separate swells, obeying different periods of succession. The tides of the first class depend on the motions of the sun and moon, the variations of the distances, and the change of their declinations. The stream tide occurs at the interval of a day and a half after the conjunction or opposition, the lunar swell at first preceding the solar, but falling back at the next two returns, till at the third accession it combines with the latter. The decrease of consecutive tides is about a third faster at the conjunctions which happen in the equinox than at those in the solstice, and nearly twice as rapid at the quadratures that occur in the equinox as at those in the solstice. Similar consequences result from the alterations in the right ascension and the declination of the sun and moon. All these conclusions of a refined theory are singularly confirmed by a critical and very laborious examination of the observations made for a series of years at the port of Brest. The second sort of oscillations is occasioned by the diurnal change of the elevation and depression of the sun; so that in midsummer, when the declination is greater, the stream tide at Brest rises seven inches higher in the morning than the following tide towards evening. This divaricating tide has no visible influence however on our shores; and to explain the equal swell of the waters during the day and the night, Laplace refers it to the retardation from a current of a certain uniform depth, which he estimated at four leagues, or eleven English miles, but has since greatly reduced it, without venturing to assign the true measure.[1] The third kind of tides, depending on the greater revolutions of the moon, have much longer periods; but their influence, however small, is traced through the observations. The immense calculations of Bouvard have detected every varying phasis of the law of Universal Attraction; but a closer approximation is still wanted to unfold separately all the terms of the disturbing forces. Some of the minute shades are indicated by a fine application of the Doctrine of Chances, and a similar process renders highly probable the existence of corresponding fluctuations in the mass of our atmosphere.

2. Mathematicians were at length prepared for investigating dispassionately the application of the great principle of attraction to all the various motions of the heavenly bodies. It had explained with beautiful simplicity the revolutions of the planets about the Sun, and of the satellites around their primaries. But to distinguish its operation in the anomalies of the general system was a most arduous undertaking. Astronomers indeed had already, from a diligent and skilful comparison of distant eclipses, detected the principal irregularities of the Lunar Motions. Hipparchus and Ptolemy discovered what are called *The Equation of the Centre and the Evection;* and after an interval of fourteen centuries, Tycho and Kepler added the *Variation and Annual Equation.* Newton not only expounded all these anomalies by the simple law of gravitation, but, probably without any helps from observation, discovered six more auxiliary equations. The Theory of the Moon, which crowns his immortal *Principia*, is a production of genius, sagacity, and invention, almost superhuman. He ascends with admirable order from the easier to the more difficult problems, reducing them always to greater simplicity; he pursues his approximations with consummate address, and seldom passing the clear bounds of geometry, or entangling his demonstrations in the labyrinth of Algebraical *formulæ*, he advances with elegance and apparently without effort to the disclosure of the most recondite truths. But it must be confessed that, in his eagle flight, he was satisfied with taking a general glance of the objects, and seldom stooped to mark the details or investigate the grounds of his calculations. He no doubt managed the research by estimating the different elements of perturbation, and supplying, as in other cases, the deficiency of the analytical process by a selection of circumstances, and the nice balancing of errors. The illustrious author himself candidly admitted the imperfection of his Lunar Theory; but what seems truly astonishing is, that in such a novel and arduous attempt he should have been guilty of so very few mistakes or omissions. The English commentators contributed very little to its extension and improvement. Machin, professor of Astronomy in Gresham College, secretary of the Royal Society, and esteemed an expert calculator, speaks of it with flippancy, and seeks only to annex a vague hypothesis, which leads to an arbitrary geometrical construction; "especially," says he, "since the greatest part of the Theory of the Moon is laid down without any proof, and since those propositions relating to the Moon's motion which are demonstrated in the *Principia* do generally depend upon calculations very intricate and abstruse, the truth of which is not easily examined, even by those that are most skilful; *and which, however, might be easily deduced from other principles* and hints of calculations which he has not produced."[2] He admits, indeed, that Theory gives only half the motion of the Lunar Apogee.

The first who improved and expanded the Newtonian Theory of the Moon was Calandrini, professor of Mathematics at Geneva, who superintended the printing of the Jesuits' edition of the *Principia* in 1739 and 1742. He investigated by a direct method the principal lunar equations, and likewise the smaller inequalities which Newton had left undemonstrated. He revised the investigation of the motion of the apsides, but was mortified to find his calculations gave only half the quantity derived from observation. The honour of confirming the Newtonian Theory of the Moon was reserved, however, for our own countrymen. Dr Stewart, the successor of Maclaurin in the University of Edinburgh, discovered the true motion of the line of apsides by a simple and beautiful geometrical procedure, in which his inventive penetration happily supplied the flexibility of the modern calculus. About the same time Walmesley,[1] an English Benedictine Monk, who afterwards attained the rank of Catholic Bishop and Apostolic Vicar, but had been compelled by religious and political bigotry to reap the advantages of a foreign education, produced in 1749, at the early age of 27, a correct analytical investigation of the motion of the Lunar Apogee, which he extended and completed in 1758.

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[1] In the last edition of the *Mécanique Celeste* he seems to have silently abandoned his calculation altogether, contenting himself with adopting the conjecture of the geographer Varenius, that the depth of the sea must bear some proportion to the altitude of the shore.

[2] *The Laws of the Moon's Motion according to Gravity*, a very short tract appended to Motte's Translation of the *Principia* which came out in 1729.

In the meanwhile, the profoundest mathematicians were directed to the right points of attack, and incited to exert all their penetration in exploring the influence of the System of Gravitation, by the prizes proposed by the learned associations on the Continent. Clairaut began his examination of the Lunar Theory in 1743. At first he was content with merely studying the Newtonian procedure, and converting it into analytical expressions; but as he became more familiar with the subject, he pushed his investigation further, and in 1747 comprised all the subordinate motions of the Moon under the famous general problem of the *Three Bodies*. But, after a prodigious exertion of ingenuity and perseverance, it was mortifying to find his solution assign for the variation of the Lunar Apogee only half the measure established by observation. Euler and D'Alembert, nearly about the same time, arrived at a similar conclusion. The followers of Newton were surprised and mortified at the result, while the adherents of the Cartesian system already began to exult in the prospect of the immediate fall of such a towering rival. In this dilemma, Clairaut, to reconcile the result of analysis with the actual phænomena, proposed, without abandoning the great principle of attraction, to modify its reciprocal gradation of intensity, by annexing to the square of the distance a small subsidiary term depending on its cube. This correction might be sufficient, from the proximity to the earth, for adjusting the Lunar motions, while it could have no sensible influence, he conceived, in affecting that duplicate ratio which directs the remote revolutions of the planets about the sun. But Buffon, who began his career with the study of mathematics, showed, from the properties of the roots of equations, that such a modification of the law of gravity involved what appeared an absurd consequence, that a body would be attracted equally at different distances. Clairaut was not shaken by this argument, which he considered as only metaphysical; yet so much discussion had been provoked, that, anxious to remove all doubts from the subject, he resumed his investigation, and pursued it with incredible labour and resolution. Carrying the approximation much farther, by computing the values of the higher terms of the series, and reiterating the process, he found the combined integrals to give exactly the double of the former result. This satisfactory conclusion, which confirmed the simple law of gravity, and restored the harmony of the universal system, was announced early in 1749. The bare mention of the fact was enough for the inventive powers of Euler, who, by quite a different procedure, soon obtained the true variation of the Lunar Apogee. If D'Alembert needed some previous information to put him in the right train, he pushed his calculations to wider extent, and approached still nearer the absolute effect. It would seem that, during this eager competition, the advances of Stewart and Walmesley were overlooked. But their countryman Thomas Simpson ventured, though considerably in the rear, to travel partly over the same ground of inquiry.

This remarkable coincidence among the first mathematicians of the age extinguished for ever any lurking suspicion of the Law of Universal Attraction. The great object of scientific research was henceforth to direct its application to the celestial motions and the improvement of practical astronomy. The rectification of the Lunar Tables, now become of such importance in the practice of navigation, was the fruit of those arduous calculations. Clairaut bestowed intense application, and digested his results into a clear form; he skilfully employed some data furnished to him by La Caille for adjusting the auxiliary equations, and thus produced Tables of the Moon's motions distinguished by their very superior accuracy. D'Alembert proceeded more slowly and neglected such aids, so that his Lunar Tables never obtained estimation with astronomers. Euler excelled both his illustrious rivals in the wonderful command of the powers of calculation; he worked with ease and rapidity, and his fertile invention continually supplied new resources and suggested other paths of advance. He suspended for a few months the further improvement of the Lunar Theory, and at the invitation of the Academy of Sciences at Paris, analyzed with all the fulness of research the influence of the mutual disturbance of the planets Jupiter and Saturn. But aiming at still higher perfection, after the interval of a few years he resumed this investigation, simplifying and greatly extending it. In the mean time he had computed a set of Lunar Tables, which he disposed in a clear method, having discovered the co-efficients of the several equations from theory alone.

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[1] Dr Charles Walmesley, born in 1722. In his latter years he resided at Bath, and took to the study of mystic theology, having written on the Revelations, and explained the Vision of Ezekiel. His papers were burnt by an antipopish mob in 1780, and he died in 1797.

About this time Mayer of Würtemburg began to distinguish himself as one of the ablest and most ingenious astronomers that has appeared in any age. In 1751 he had been appointed director of the observatory at Göttingen; and in this situation, encircled by foreign troops, and exposed to the danger of powder magazines, he yet laboured with such intense and enthusiastic ardour as to shorten his days. His efforts were mainly directed to the improvement of the Tables of the motions of the Sun and Moon. These elements he derived from a discussion of numerous observations of eclipses and occultations, and he borrowed little from theory, though he preferred the arrangement of the elements adopted by Euler. He was the first who employed the method of conditional equations to find the true values of the co-efficients. His Tables were inserted in the Göttingen Transactions; and after the most sedulous correction, he sent them in 1755 to London, for the patronage of the Board of Longitude. At his death in 1762 he left two copies, greatly improved, one of which his widow transmitted to that scientific body. After long and protracted deliberations, the modified prize of L.3000 was at last awarded to his family, with a present of L.300 to Euler, for his excellent formulas. But another more complete copy having been afterwards presented, the Board of Longitude bestowed an additional reward of L.2000 at the instance of Dr Maskelyne, who zealously undertook the charge of editing those Tables in 1770.

The exertions of the continental mathematicians were now successfully directed to the investigation of the disturbing influence or mutual perturbations of the larger and nearer planets. Euler in 1747 sent to the Academy of Sciences at Paris a most ingenious memoir on the derangement of Saturn's motion, occasioned by the superior attraction of Jupiter. It was not only the first solution of the problem, but the simplest and most direct, referring the forces exerted to three perpendicular co-ordinates. He then discovered the beautiful principle in celestial mechanics, that there exist really no *secular equations*, but that all the deviations from the regular course are strictly *periodical*, and return always in the same order, though separated at vast intervals. Notwithstanding the exuberance of his analytical resources, he was yet obliged to omit the smaller quantities, and to adopt certain admissible suppositions, in order to shorten the immensity of the calculation. But being again recalled to the consideration of the subject, he produced, four years afterwards, another dissertation, which surpassed all his former efforts, and obtained the double prize of the Academy. The great analyst new-modelled his investigation, rendered the process much simpler and clearer, pursued the approximations farther, and arrived at more accurate results. He found that the mean motions of Jupiter and Saturn are equally subject to a very slow increase or diminution, which alternates however in the lapse of 15,000 years. But Euler was induced to push those researches still farther, and gained the prizes proposed by the Academy for the years 1754 and 1756, by his theory of the inequalities in the Earth's motion, caused by the planets. The three methods of investigation that he proposed were all of them quite different; and nothing seemed more astonishing than the facility with which his prolific invention struck out new paths. He discovered four small anomalies to result from their combined attractions, though it was scarcely possible, for want of proper data, to assign the precise measures of those aberrations. He ventured, however, to estimate the mean progression of the aphelia at 12 seconds annually, and the diminution of the obliquity of the ecliptic, which some astronomers still doubted, at 49 seconds in a century. He found that the eccentricities of the aphelia of Jupiter and Saturn are periodical, and complete their cycle in the space of 30,000 years. By an inverted application of the same principles, it was possible, by computing the co-efficients of the formulæ from actual observations, to determine the masses of those planets which are not accompanied by satellites. Euler hence found that Mars contains rather less matter than the Earth, and Venus only about the half, but which by a subsequent calculation he nearly doubled. The process was too much involved to secure entire confidence in the results; and the rapidity and extent of his calculations had led to occasional mistakes.

The same subject was in 1757 discussed by Clairaut, in a clear and concise manner. By comparing his *formulæ* with the accurate observations of La Caille, he determined very nearly the masses of the principal planets, and showed that the greatest effect of their accumulated influence in deranging the Earth's motion can amount only to about a minute. His estimate of the attraction of Venus has been confirmed by later and more elaborate calculations.

In 1749 D'Alembert investigated rigorously the effects arising from the Moon's attracting the spheroidal prominence of the Earth. By the transformation of his general expressions, he found the *Precession*, or conical motion of the terrestrial axis about the poles of the ecliptic, to be 50 seconds annually, and its *Nutation* or alternate vibration on the same plane only 18 seconds during the period of the revolution of the Lunar Nodes. Comparing this quantity with observation, he concluded that at the surface of the Earth the attraction of the Sun is to that of the Moon as 3 to 7, which makes the satellite to have only the 70th part of the mass of our planet.

The powers of calculation were now turned to the erratic class of the celestial bodies, so long the objects of superstitious terror, but which Newton had likewise subjected to the great law of gravitation. While the planets revolve in ellipses approaching to circles, and lying nearly in the plane of the ecliptic, the comets describe elliptical orbits with very different inclinations, and so extremely elongated as to resemble parabolas through a considerable part of their course. Being very small, they are seen for a short space only in the vicinity of the Sun, but become quite invisible during their distant excursive journey beyond perhaps the boundaries of our planetary system. The periodic time of a comet, depending on the length of the transverse axis of its ellipse, can seldom be determined with any sort of accuracy. The few observations that can be made in the transient interval of its apparition are scarcely sufficient to assign its mean motion and the places of its nodes and perihelion. Newton, while he proposed the parabolic theory as sufficiently correct in the visible portion of the cometary track, gave two elegant constructions for discovering the elements of the curve from three proximate observations. Halley applied those principles to the laborious computation of twenty-four remarkable comets. But his attention was more especially fixed on the nearest of them, which had been observed in 1531, 1607, and 1682, and seemed to be the same with one noticed by chroniclers in 1080, 1155, 1230, 1305, 1381, and 1456,[1] and hence performing its revolutions in about 75½ years; he therefore ventured to predict its return about the end of 1758 or the beginning of 1759. In arriving at this conclusion he was equally fortunate and circumspect; he found that the comet must suffer great derangements in its passage through our planetary system, from the attractions of Jupiter and Saturn, which he endeavoured to calculate, though with very doubtful success. The time of the expected return approaching, excited intense curiosity in the philosophical world; and Clairaut was induced to apply his formulæ in the investigation of the progress of the comet, which, after immense labour in calculation, assisted by several expert computers, he announced at a public meeting of the Academy of Sciences on the 14th of November 1758. He found that the last revolution would be retarded about 618 days longer than the former, not reaching the perihelion till the middle of April 1759. But on revising his computation, he reduced that term to the 4th of April, exceeding that of observation by 12 days only, a discrepancy owing probably to the influence of the remote planet Uranus, which was not yet discovered. The comet was first seen by a peasant in Saxony on Christmas-day, but soon became the admiration of Paris, and procured for Clairaut the enthusiasm of popular applause. This remarkable erratic star, though visible only for a few months, had journeyed five years within the orbit of Saturn, though it never stretched its excursion to twice the distance of Uranus. It approached so near to the Earth as would have disturbed her motions, if its mass had not been extremely small.

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[1] This would seem to be the comet whose appearance after the capture of Constantinople by the Turks spread terror through Christendom, and which pope Calixtus III. so devoutly exorcised in the same anathema with these dreaded infidels.

The success and popularity of Clairaut drew some peevish reflections from D'Alembert, whose formulæ, if he had taken the trouble to pursue their application, would have led to similar results. Euler, whose researches on Comets were still more extensive and diversified, viewed this triumph of ardent exertion with the calmness and magnanimity of a sage. But Clairaut, eager to complete a work in which he had gathered so many laurels, next proceeded to calculate the disturbing influence of Jupiter and Saturn on the place of the nodes of the comet of 1682 and 1759, which has an inverted motion. Newton had shown that the perturbations in the planetary system always advance the perihelion and retract the nodes; but the case here was just reversed, and the quantity of recession thence determined agreed most exactly with observation.

So gleamed the last efforts of a philosopher who happily united the highest vigour of intellect with suavity of manners and elegance of conversation, but whose days were shortened by excessive labour, and the seductions of refined society, which incessantly courted and caressed his presence. Clairaut died on the 17th May 1765, at the age of 52, deeply regretted by a very numerous circle of friends, and leaving imperishable monuments of genius.[1]

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[1] A tribute of warm respect is paid to the memory of Clairaut by the celebrated but unfortunate Bailly, who thus eloquently pleads the cause of abstract science:—

"Le portrait de M. Clairaut seroit celui du véritable Géometre. Un Géometre est un homme qui entreprend de trouver la vérité; et cette recherche est toujours pénible, dans les sciences comme dans la morale. Profondeur de vue, justesse de jugement, imagination vive, voilà les qualités du Géometre: profondeur de vue, pour appercevoir toutes les conséquences d'un principe, cette immense postérité d'un même père; justesse de jugement, pour distinguer entr'elles les traits de famille, et pour remonter de ces conséquences isolées au principe dont elles dépendent. Mais ce qui donne cette profondeur, ce qui exerce ce jugement, c'est l'imagination; non celle qui se joue à la surface des choses, qui les anime de ses couleurs, qui y répand l'éclat, la vie, et le mouvement, mais une imagination qui agit au-dedans des corps, comme celle-ci au-dehors. Elle se peint leur constitution intime; elle la change et la dépouille à volonté; elle fait, pour ainsi dire, l'anatomie des choses, et ne leur laisse que les organes des effets qu'elle veut expliquer. L'une accumule pour embellir, l'autre divise pour connoître. L'imagination, qui pénetre ainsi la nature, vaut bien celle qui tente de la parer; moins brillante que l'enchanteresse qui nous amuse, elle a autant de puissance et plus de fidélité. Quand l'imagination a tout montré, les difficultés et les moyens, le Géometre peut aller en avant; et s'il est parti d'un principe incontestable, qui rende sa solution certaine, on lui reconnoît un esprit sage; ce principe le plus simple, offre-t-il la voie la plus courte, il a l'élégance de son art; et enfin il en a le génie, s'il atteint une vérité grande, utile, et long-tems séparée des vérités connues!

"Aucune de ces qualités n'a manqué à M. Clairaut; les preuves sont de l'histoire de la Géométrie, les succès seuls sont de notre ressort. L'Astronomie lui doit des progrès difficiles; nous le jugeons ici par ce qui intéresse les hommes, et sur ce qu'il a fait d'utile. La théorie de la lune restée imparfaite dans les mains de Newton, le cours des cometes calculé, leur retour prédit, en rendant compte des causes qui le retardent ou qui le précipitent; voilà ce qui restoit à faire depuis Newton, depuis Halley; et voilà ce que M. Clairaut a fait. Cela étoit difficile, puisque deux grands hommes y ont été arrêtés; cela étoit utile, parceque la connoissance des mouvemens de la lune amenera la perfection de la géographie et de la navigation, parceque la prédiction du retour des cometes caractérisera notre siecle et fera sa gloire. Le principal mérite

But the Theory of Comets still remained incomplete. Those excursive bodies, in traversing our system, often suffer such derangement from the influence of the proximate planets, that the most select observations are insufficient to determine with any sort of precision their elliptical orbits. The famous comet of 1759 was calculated by Euler and Lexell to perform its revolution in a space between 449 and 519 years, while Pingré assigned it the period of 1231 years. In some cases the observations have indicated an hyperbolic orbit. Conti, following the method of Gauss, found the comet of 1811 to revolve in 3056·3 years; but by a second computation he reduced the time to 2301 years. The profound and experienced calculator Bessel lately gave the comet of 1807 a period of 1953·2 years, which he next brought down to 1483·3. The attraction however of the Earth would increase this to 1713·5 years, while the influence of Jupiter would reduce it again to 1543·1 years. Although the process of calculation be now greatly improved, the return of a new comet cannot be safely predicted. Our expectations can acquire confidence only from a comparison with former appearances.

Though the comets suffer such derangement from the action of the larger planets, they have no sensible influence on our system. They must therefore be extremely small, consisting of a dark nucleus, invested with a cloudy or hazy excrescence, and generally provided with very long sweeping tails. They have never disturbed our tides; though, having sometimes approached within the third part of the distance of the Moon, they would consequently with the same mass exert twenty-seven times greater deranging force. But their passage was then so rapid as not to allow the accumulation of impulse required to heave the wide expanse of ocean.

Comets are distinguished by the elements of their orbits, derived only from observations made near the perihelion. Newton gave an elegant method of discovering those paths, by a geometrical construction grounded on the parabolic theory, and embracing three distinct observations. But this solution is liable to much uncertainty in its application, and Boscovich has shown how in most cases it merges in a porismatic or indefinite result. Mathematicians have therefore employed the resources of analysis in the resolution of this problem. Euler, besides the three consecutive observations, adopted a fourth one more remote, and thus obtained an accurate but very tedious and involved process. Lambert derived a different mode of solution from some general properties which he discovered of the Conic Sections in 1761. He employed calculation combined with a graphical process, and sought to abridge the labour, by help of a table of the descents of comets, or the motions which they would perform if their parabolic paths collapsed into straight lines. Thomas Simpson, the only person in our island who at this time appeared to emulate the Continental mathematicians, likewise produced ingenious disquisitions on the Comets, and framed similar tables. Hennert, Tempelhoff, and Sejour, afterwards pursued the same subject, which has since been discussed with great ability by Lagrange, Laplace, and Legendre. Other methods for discovering the orbits of comets have been more recently proposed by Delambre, Olbers, and Gauss; the last of which may be considered as the most elegant and complete. But all these analytical modes of solution are still very tedious and complicated; insomuch that the humbler procedure by the way of *Trial and Error*, or what is called *False Position*, is found in practice to be on the whole the shortest and most satisfactory.[1]

While the sublimer geometry thus gradually disclosed the various recondite anomalies which

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de M. Clairaut fut le talent des applications : malgré son génie, il n'étoit point rebuté des détails ; il pensoit qu'une vérité de pratique étoit préférable à celles qui restent ensevelies dans vingt pages d'analyse ; aussi n'a-t-il fait que des choses utiles. Son nom a été connu, porté partout, et sera répété dans les âges. Si nous avons osé le louer, c'est que l'Astronomie lui doit de la reconnoissance, c'est que nous sommes au moment où la postérité commence pour lui. La vérité peut élever une voix franche et libre, et nous ne sommes que son organe." (*Histoire de l'Astronomie Moderne*, tome iii. pp. 197, 198.)

[1] The most accessible work that has recently appeared on this very difficult subject is the *Essay on Comets*, which gained the first of Dr Fellowes' Prizes in the University of Edinburgh, and which reflects such credit on its youthful author, David Milne, Esq. advocate.

affect the planetary motions, and yet maintain the balanced harmony of the universe, a genius of the first order arose, and placed himself at once on the summit beside the chief mathematicians of the age. In 1759 Lagrange, when only 23 years old, gave a new extension to the Integral Calculus, under a form which has obtained the appellation of the *Calculus of Variations,* and applied this with singular address to the rigorous solution of the very difficult problems of the propagation of sound, and the vibration of a musical chord. His early progress was hailed by Euler, and encouraged by D'Alembert. No mathematician has ever displayed a completer command of the Calculus than Lagrange, who rivals Euler himself in clearness, elegance, and fertility of invention, and eminently surpasses that great master of analysis in the justness and expansion of his philosophical views.

The next effort of Lagrange obtained him the prize offered by the Academy of Sciences at Paris in 1764, for his Discourse on the Libration of the Moon, in which he most satisfactorily explained, from the theory of Attraction, the cause of the Moon's presenting always nearly the same face towards the Earth. He arrived directly at the same general equations as D'Alembert, by a happy combination of the dynamical principle of that philosopher with the property of virtual velocities, which was the germ of his capital work on *Analytical Mechanics.* This subject he again resumed in 1780, and discussed it in the fullest and most accurate manner, having succeeded in completing the integration of the chief equations.

The theory of Jupiter's Satellites is not only an object interesting in speculative science, but of great importance in the practice of astronomical observation for finding the longitude. Bailly, applying merely the formulæ of Clairaut, obtained an imperfect solution of their periodic motions. In 1766 the genius of Lagrange embraced this subject in its full extent, by introducing into his equations not only the attractive force of the Sun, but the mutual attractions of the Satellites themselves. He neglected no term which might sensibly affect the results, and advanced with caution and address by successive approximations. His investigation was a model of analytical research; yet, though capable of extensive application, it did not descend into all the practical details.

The Lunar Theory still presented difficulties which it required the utmost efforts of genius to abridge and partially remove. In 1768 D'Alembert simplified the evolution of the disturbing forces, by projecting orthographically the moon's orbit on the plane of the ecliptic. Euler, in conjunction with his son Albert, now gave the completest solution of the general problem that had yet appeared; but having discovered no indication of a secular equation affecting the Lunar motions, they were inclined to doubt its existence. This arduous discussion was repeated in 1772, on which occasion Lagrange shared the prize with the Eulers. Two years afterwards he resumed the subject, and closely examined the different conditions annexed to the programme. There are five elements of a planet's motion liable to the influence of Disturbing Forces: 1. The Great Axis of the primary ellipse; 2. The Eccentricity of the orbit; 3. The Inclination of its plane; 4. The position of its Nodes; and, 5. The direction of its line of Apsides. In 1776 Lagrange demonstrated that the great axis, on which depends the period of revolution, has no term involving the lapse of time, and therefore cannot be affected by any *Secular Equations,* which constantly increase or diminish. But with regard to the mean motions of Jupiter and Saturn, Lagrange and Euler came to opposite conclusions, the one exhibiting a continual acceleration, and the other a like retardation.

Laplace, who has attained still higher celebrity, now appeared on the scene. Displaying the same faculty of invention, he possessed nearly equal skill in the management of the *Calculus,* without reaching, however, the clearness, simplicity, and elegance of his illustrious rival. But he ranged over a wider field of discovery, and exerted greater and more persevering industry, and pressed forward with a loftier feeling of ambition.

In 1773 Laplace, following the steps of Lagrange, adopted a new mode of investigation, and pushed his calculations farther. Instructed by the successive advances of his predecessor, he proved in 1775 that the mean motions of Jupiter and Saturn have no secular equations, but perform all their changes within certain long periods, which hence reconciles the discordant conclusions of Euler and Lagrange. Having found that the variation of eccentricity of Jupiter's orbit must cause a corresponding alteration in the motion of the Satellites, Laplace transferred the same idea to the perturbations of our Moon, and thus discovered the true theory of her secular equation, or rather of that vast cycle in which the lunar revolutions are alternately accelerated and retarded. This very slow but gradual diminution of the moon's periodic motion, which the intermediate observations of the Arabian Astronomers, between Hipparchus and Bradley, have incontestibly established, was at one time referred to the resistance from an ethereal fluid imagined to occupy the celestial spaces. Laplace at first conceived that the retardation might be explained on the hypothesis of a progressive transmission of the power of Attraction, and computed that it would require 8000 times the celerity of Light, which travels 200,000 miles in a second, to produce this effect. But his subsequent inquiries having shown that Gravity must dart its influence more than 50 million times faster than Light, we may therefore safely consider it as quite instantaneous. This conclusion is highly important in a philosophical view, since it sets for ever at rest the various speculative attempts to explain the cause of Attraction by the agency of certain mechanical *intermedia*, and demonstrates it to be a primordial and ultimate principle ordained by the Wisdom of the Supreme Architect.[1]

In the meanwhile Lagrange had in successive dissertations investigated the secular variations of the planets by a new and direct process, which he conducted with incomparable address and elegance. Nor did he confine his researches merely to theory, but applied the *formulæ* to the motions of the five planets then known. In a subsequent investigation he most skilfully separated the terms of the equation which exhibit the secular deviations, from those which represent the periodical changes.

The soaring rivals appear alternately to surpass each other. Laplace, continuing his researches, at last discovered, that the secular equation of the Moon affecting her mean motion and that of her perigee and of her nodes in the ratio of 4, 12, and 3, is produced by the slow variation of the solar attraction occasioned by the changing eccentricity of the Earth's orbit resulting from the influence of the larger planets, though they cannot alter the great axis which determines the mean periodic revolution. Lagrange then showed that the same results were deducible from his general *formulæ*. In 1785 Laplace resumed his investigation of the motions of Jupiter and Saturn; and suspecting that Euler and Lagrange had not carried their approximation sufficiently far, he pushed his calculations from the second to the fourth powers of the eccentricities of their orbits, and proved that those planets can have no secular equations. But, having remarked that their mean periods are commensurable and very nearly as 2 to 5, he found their reciprocal acceleration and retardation to follow the same ratio. The cycle began in 1560, and comprehends 929 years; so that at the epoch of 1750 Saturn had his period shortened 48′ 44″, while that of Jupiter was lengthened by 19′ 28″. In 1788 he discovered two curious laws that connect the periods of Jupiter's Satellites, and gave a complete theory of their motions, which served as the basis of Delambre's excellent Tables.

After an interval of several years, during which Lagrange had totally suspended his mathematical studies, he returned to his early pursuits with all the freshness of youthful invention, and all the vigour of matured and improved intellect. In 1808 he gave a most general solution of the problem of Disturbing Forces, and by a wonderful effort of sagacity he reduced his equations into a form of the utmost simplicity and elegance.[2]

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[1] It is rather singular that Laplace should on several occasions betray a disposition towards materialism, while his investigations point evidently to an opposite inference.

[2] Since all observations are liable to incidental inaccuracies, it requires great address to balance the opposite errors. The ordinary way is to take the arithmetical mean; but this mode confounds equally the remote and the approximate indications. Cotes, in his *Estimate of the Errors of Observation*, proposed an ingenious and more accurate mode of investigation,

The eighteenth century was equally distinguished by the progress of Practical Astronomy. Observatories were greatly multiplied and widely dispersed over the surface of the globe, the art of making observations was brought to higher perfection, and instruments of more delicate construction were successively introduced. Besides the great problems of the figure of the Earth and the nutation of her axis, we may enumerate four capital improvements: The measure of celestial refraction—the determination of the parallaxes, and consequently the mean distances of the Moon and Sun—the discovery of new planets and satellites—and the enlarged survey of the heavens, comprising the groups and various modifications of the fixed stars.

1. *Celestial Refraction.* A ray of light passing obliquely from a rarer into a denser medium, is bent or refracted towards the perpendicular. The light emitted by the heavenly bodies, when it enters our atmosphere and descends to the surface through a succession of condensing strata, must evidently describe an incurved path; and the particles which reach the eye and produce vision, pursuing the direction of the terminal tangent, will give to a star an apparent elevation. The portion of the trajectory traced in approaching the surface of the Earth may be considered as an arc of a circle having its radius about six times greater. The quantity of refraction is hence nearly proportional to the tangent of the altitude.

Hawksbee had in 1710 found by a nice experiment, that the refractive power of air compared with that of water is in the ratio of its density; and this law was ascertained by Biot and Arago about a century afterwards to be general in our atmosphere. Hence refraction of that medium increased with the elevation of the barometer or the depression of the thermometer. The effect of cold was early remarked by the Dutch Arctic voyagers; but Bouguer first accurately observed the diminished agency of attenuated air during his sojourn on the summits of the Andes. Yet without demonstration Bradley gave a simple rule for computing the celestial refraction, and Mayer adopted another nearly similar. Thomas Simpson, in a very ingenious dissertation, derived a formula which is substantially the same. The subject of refraction has likewise been discussed by Lambert, Kramp, Fontana, and more recently by Laplace, Gauss, Bessel, Young, and Ivory. The formula of Laplace is complicated and inelegant, while Ivory's method seems clear and simple.

2. *The Lunar and Solar Parallaxes.* The nearer celestial bodies are seen from the surface of the Earth in a position somewhat different than if viewed from the centre. This deviation, termed *parallax*, is obviously greatest at the horizon, and diminishes constantly in approaching to the zenith. To ascertain parallax with any precision, it is therefore required to institute observations at distant stations. It was chiefly for this purpose that La Caille selected the Cape of Good Hope, where he determined the mean parallax of the moon to be 57′ 39″. But the parallax of the sun, being so small a quantity, is much more difficult to find. Kepler had taken it for a minute, Halley reckoned it at 25″, but subsequent astronomers had generally reduced the estimate to 10 seconds. To determine this element with accuracy, Halley proposed a very ingenious method from the next transit of Venus, by measuring the acceleration and retardation of the time of her passage over the disc of the sun as viewed from remote points on the surface of the globe. He could not expect his life to be prolonged till that event, but he warmly exhorted his successors to prepare them-

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which, reduced to its simplest form, consisted in projecting the several *data* on a plane, and assigning their common centre of gravity for the true result. Euler disposed the observations into conditional equations with indeterminate co-efficients, which he traced out by successive eliminations. Mayer adopted the same plan, and employed it most extensively in the construction of his valuable Tables. But this procedure being very laborious, Legendre proposed to abridge it by the method of the *least squares*, which had likewise occurred to Gauss, being generally used by him in the reduction of observations. It was a fine application of the Doctrine of Chances. Various algebraical investigations of the principle have been given; but they are commonly very intricate and abstruse.

Mathematicians, in threading the labyrinths of analysis, seem to have overlooked a most simple and luminous demonstration furnished by the Ancient Geometry. From an elegant proposition of the *Loci Plani*, it follows as a corollary, that the sum of the squares of the distances of any number of points from their centre of gravity is a *minimum*; which therefore merges in the solution of Cotes.

selves for observing it on the 5th of June 1761. Astronomers were accordingly dispatched by the several maritime powers of Europe to all the stations that were considered as the most eligible and accessible. Owing to various accidents, however, the results did not answer the expectations raised. The stations had not been always the best chosen; some of the most expert observers did not reach their proper destination, others were obstructed in their operations by the state of the weather, and many difficulties generally occurred which had not been provided for. From a comparison of the collected observations, Pingré deduced a parallax of 10½″, while Short made it only 8½″. Such a discrepancy was mortifying, and astronomers looked forward with impatience to the succeeding transit of Venus, which was fortunately to happen within the space of eight years, though such an occurrence would not take place again till the 8th of December 1874. In the meanwhile Dr M. Stewart revived an idea of Machin, who, from a rude computation grounded on the motion of the Moon's Nodes, estimated the Solar parallax at 8″. He preferred however the change of the apogee, or of the direction of the principal axis, which is affected in some degree by the sun's distance. By the application of the Greek Geometry alone, Stewart had with profound ingenuity achieved the solution of a problem which so long baffled the address of the great masters of the modern calculus; but in pursuing his deductions, the passion for purity and elegance of demonstration led him to hazard so many simplifications, as to render the conclusion, amidst a balance of errors, very doubtful and precarious. He reduced the parallax to 6·9″, which from its smallness excited considerable surprise.

The uncertainty regarding the sun's real distance was finally removed by the skilful and numerous observations of the Transit of the 3d of June 1769. The several results differed scarcely the quarter of a second, and their concurrence fixed the parallax at 8·6″. This likewise agrees with the theoretical calculations of Laplace from the Lunar anomalies. But Bessel, having with immense labour combined and carefully recomputed the original observations, has recently detected a small correction, which makes the parallax to be only 8·575″, and consequently the mean distance of the sun 95,158,440 English miles.

3. *Discovery of New Planets and Satellites.* It was an inveterate opinion, derived from the ancient Pythagoreans, that the number of the great celestial bodies must of necessity be six, the first *perfect* number, or one which contains all its subdivisions. When Galileo directed his tube to the heavens and detected some of the satellites of Jupiter, this notion retarded the assent of the learned to his discovery; but after Saturn was found to be accompanied likewise by satellites, speculative philosophers sought to extend the catalogue of revolving stars to 28, the next perfect number. In this expectation, however, they were disappointed, and the Solar System received no further accession for the space of a century. The discovery of a New Planet was reserved for our own times.

Herschel, a musician residing at Bath, though a native of Hanover, which he had left in early youth, devoted his leisure to the construction and improvement of reflecting telescopes, with which he continued ardently to survey the heavens. His zeal and assiduity had already drawn the notice of astronomers, when he announced to Dr Maskelyne, that, on the night of the 13th of March 1781, he observed a shifting star, which from its smallness he judged to be a Comet, though it was distinguished neither by a nebulosity nor a tail. The motion of the star, however, was so slow as to require distant observations to ascertain its path. It was for several months presumed to be a Comet; but the hypothesis of a parabolic orbit led to very discordant results. The president Saron, an expert and obliging calculator, was the first who conceived it to be a Planet, having inferred from the few observations communicated to him, that it described a circle with a radius of about twelve times the mean distance of the Earth from the Sun. Lexell removed all doubt, and before the close of the year he computed the elements of the New Planet with considerable accuracy, making the great axis of its orbit 19 times greater than that of the earth, and the period of its revolution 84 years. Bradley, mistaking it for a fixed star, had observed it on the 3d December

1753; and it was again seen by Mayer on the 23d September 1756.

Herschel proposed, out of gratitude to his Royal Patron, to call the planet he had found by the barbarous appellation of *Georgium Sidus;* but the classical name of *Uranus,* which Bode afterwards applied, is almost universally adopted. Animated by this happy omen, he prosecuted his astronomical observations with unwearied zeal and ardour, and continued during the remainder of a long life to enrich science with a succession of splendid discoveries. But Herschel also detected the satellites that accompany his planet, amounting to six, which revolve in a plane nearly perpendicular to its orbit, and contrary to the order of the signs. Both these primary and secondary bodies obey, in the relation of their motions and distances, the great law of Kepler. The same conformity obtains in the revolutions of the satellites of Saturn, which he increased to seven; and thus every step in the progress of astronomy gives additional solidity to the grand system of attraction.

Some German philosophers, indulging their curious fancy, have traced among the distances of the planets an analogy, which, though not strictly accurate, yet approximates so near the truth, that if not really founded in nature, it may at least assist the memory. Kepler, whose ardent imagination inflamed all his speculations, believed that the harmony of our system wanted a planet between Mars and Jupiter. A similar notion was entertained by the ingenious Lambert, who further supposed it might be dark and invisible. Reckoning from Mercury, the first of planets, and assuming as the unit of measures its interval from the sun, the intervals of the rest will be expressed by the binary progression 2, 4, 8, 16, &c.; and consequently the distances of the series of planets from the sun may be represented by the numbers 1, 2, 3, 5, 9, 17, 33, 65, &c. While 3 denotes the distance of the Earth, and 17 and 33 indicate the distances of Jupiter and Saturn, the remote Uranus has come to occupy the place marked by 65. But a planet at the distance 9, between 5 and 17, the distances of Mars and Jupiter, was still wanting to complete the regular sequence. Bode slightly modified these proportions, and attained greater accuracy, at some expense, however, of simplicity. Taking the number 4 to express the interval of Mercury, he multiplied the terms of the binary progression by 3. The distances of the planets from the Sun are hence denoted by the series 4, 7, 10, 16, 28, 52, 100, 196, &c. which numbers are convertible into English miles by multiplying by 9½ millions. The dark or deficient planet, corresponding to 28 or the distance of 266 millions of miles, is now supplied by the discovery of four very small stars, which have been fancifully conjectured to be only fragments dissevered from the principal, while other portions, still unobserved, are whirling through space. The detection of those singular planets distinguishes the commencement of the nineteenth century. Piazzi discovered Ceres at Palermo on the 1st of January 1801, Olbers at Bremen found Pallas on the 28th of March 1802, and his countryman Harding added Juno on the 2d of September 1804, and Vesta on the 29th of March 1807. These *asteroides,* as they have been called by Herschel, differ from other planets not only by their diminutive size, but by the remarkable inclination of their orbits to the plane of the ecliptic, which, however, they intersect nearly in the same nodes.

This wonderful extension of the Solar System was chiefly due to the zeal and industry of the German and other confederated Astronomers, who, at the instance of the spirited Baron Zach, had divided the heavens into different sections, and occupied themselves in surveying their several allotments. The catalogue of fixed stars was thus prodigiously augmented, and many peculiarities in their character and configuration detected. In the meanwhile Herschel, with the superior aid of his powerful reflecting telescopes, observed the numerous clusters of nebulosities, and distinguished many of the changing and double stars, which, though suns of other systems, yet appear connected, and may probably circulate about their common centre of gravity. Assuming that the instrument he used could enable him to penetrate 497 times farther than Sirius, he reckoned 116,000 stars to pass in a quarter of an hour over the field of view, which subtended an angle of only 15′. If we compute from such a narrow zone, the whole celestial vault must display, within the range of telescopic vision, the stupendous number of more than five billions of fixed stars. Imagination is bewildered in the immensity of such prospects. But a sober retrospect of the progress of astronomy would aid our conception of the structure and harmonious adjustment of the universe.

"To generate a circular description, it is requisite that the body should have the precise celerity due to a fall through half that radius. But, projected with inferior celerity, it would, about the same axis, trace elliptical orbits more or less compressed; the foci mutually retiring towards the extremities, while the conjugate diameter contracts. When the primary impulsion becomes extinct, the elongated ellipse merges in a straight line. On the other hand, if the projectile motion should exceed the limit of circular velocity, a new series of curves will arise. But when the acceleration is directly as the distance, on passing the limit of celerity, the foci will first unite in the centre, and the axis suddenly turning at right angles, the foci will now gradually dispart in this transverse position. As the velocity of impulsion is successively augmented, the ellipse will assume all the degrees of oblateness, till it finally vanishes in two parallel lines.

"If the centripetal force be inversely as the square of the distance, the moment the primary impulsion transcends the limit due to a circular trajectory, the orbit would suddenly change into an equilateral hyperbola; the farther focus, which had come to coalesce with the attractive one, now flying to the opposite side beyond the diameter. When the celerity of projection receives a farther increase, the incurvation at the vertex will be proportionally diminished. With an extreme impulsion, the body would shoot off in a straight line perpendicular to the axis.

"It thus appears, that a circular revolution, which the ancients so fondly contemplated as the perfection of the celestial movements, is incompatible with the stability of the universe. The most absolute precision of impulse would have been necessary, and the very slightest subsequent addition of celerity, from the incidental influence of those disturbing forces which are incessantly in operation, would at once have transformed the circle into a hyperbola, and have carried the planet away for ever into the boundless expanse of heaven. In viewing the grand phenomena of nature, our admiration is drawn to those conservatory principles which, in shorter or longer periods, correct every occasional deviation from the general balance of the system.

"It is curious, however, to remark how very nearly the planetary orbits approximate to circles. In that of our earth, the two axes differ only by the 7086th part. In the trajectory of Mars, this difference amounts to the 231st part. It was accordingly the greater eccentricity of that orbit which led Kepler to detect its elliptical form. The group of small kindred planets lately discovered revolve in curves still more elongated, the diameters of those of Juno and Pallas being nearly in the ratio of 30 to 29. These singular bodies might seem to rank between the ordinary planets and the comets, which wander in ellipses of extreme elongation, scarcely distinguished from parabolas, during a great part of their visible track. In another circumstance, too, the analogy obtains; for while the larger planets deviate not more than 2 or 3 degrees from the plane of the ecliptic, Pallas crosses it at an angle of 35°, and the paths of the comets have every possible inclination. It remains to be discovered, whether diversified bodies, travelling in the celestial spaces, may not fill up more completely that prolonged gradation of existence, which appears so conspicuous in other parts of nature. Supposing the projection of the planets to be the result of some more general law, those which had an excess of impulsion would totally escape our range of observation, being swept away in hyperbolas into boundless space, there perhaps to form other stellar systems."[1]

The ingenious Lambert produced some curious speculations respecting the celestial bodies. He presumed that the various planetary systems are all connected, and revolve about a common centre, which Galileo had conjectured to be situate in Orion or Sirius. The planets, therefore, do not strictly describe ellipses, but a series of convoluted epicycloids. He showed that comets, in passing the nearest planets, might have their orbits changed into parabolas or even hyperbolas, and hence journeying from system to system, would perform the tour of the universe. Those erratic bodies he peopled with a race of contemplative astronomers, who, enjoying such peculiar advantages, could survey the whole extent of the starry frame.

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[1] *Elements of Natural Philosophy*, pp. 123–125.

Lambert remarks, that, between the 16th and 17th centuries of our era, we have been visited by 40 comets that have not appeared again. These must, from their brilliancy, have reached the earth's orbit, and perhaps come within the verge of Venus and Mercury. But the very elongated cometary paths might descend in various directions without interfering with the planets. Calculating on the principle of chances, he found that no fewer than 500,000 comets might have the *aphelia* of their ellipses situate in the orbit of Saturn. But if we extend this computation to the orbit of Uranus, we may reckon up *two millions* of comets, as probably the number of those erratic attendants of our system. Mr Milne carries the estimate still higher. Assuming a thousand years for the average period of the revolutions of the comets, it would require to multiply by ten the 140 which have been observed within the earth's orbit during the last hundred years, giving 1400 for the whole of such near visitors. But Uranus being twenty times more distant, the product of the cube of this, or 8000 into 1400, exhibits 11,200,000 as the approximate number of all the comets which range within the known extent of our system.

The periodical change of the inclination of the ecliptic is at last established, though the quantity of variation and the length of its cycle have not been absolutely determined. Schubert, in his treatise of Practical Astronomy, makes it to fluctuate between 18° and 29°, altering in the space of 65,000 years from 27° 45′ to 20° 43′; the maximum having occurred at the remote period of 36,300 years. But Delambre and Piazzi, whose judgment and scientific attainments rank much higher, have reduced this aberration within the moderate limits of 1° 20′. The greater obliquity of this ecliptic in ancient times, by elevating the sun more in summer, and depressing him in winter, must have proportionally increased the diversity of the seasons. But still the mean temperature of the earth has continued for ages exactly the same; for the momentum of rotation at first impressed remaining necessarily invariable, the smallest rise of heat, expanding the revolving mass, must have retarded its motion, and consequently lengthened somewhat the day. Any decrease of heat, on the contrary, would accelerate the terrestrial rotation. Now, the length of day has certainly not altered a single second of time since Hipparchus observed eclipses 3000 years ago; and it therefore follows, that during this long period the mean temperature of the earth has not varied the fraction of a degree. The constant accession of heat from the sun must hence be consumed by some process yet unexplored. Unless this heat were again to resume the form of light, it could not be darted from the upper atmosphere through the boundless void. Since the waters of the ocean are colder in proportion to their depth, might we not suppose the bottom to be frozen, and all the surplus heat to be absorbed in melting the subaqueous ice?

Astronomical considerations likewise elucidate the internal structure of our globe. The mean density of the mass is about double that of its exterior crust. But if the general materials were the same, and the law of compression subsisted in any degree, the resulting condensation would be inconceivably greater. Air compressed into the fiftieth part of its volume was lately found in France to have its elasticity fifty times augmented; and had it continued to contract at this rate, it would from its own incumbent weight have acquired the density of water at the depth of 34 miles. But water itself would have its density doubled at the depth of 93 miles, and even attain the density of quicksilver at a depth of 362 miles. In descending therefore towards the centre, through the space of about 4000 miles, the condensation of ordinary materials would surpass the utmost powers of conception. "It seems therefore to follow conclusively, that our planet must have a very widely cavernous structure, and that we tread on a crust or shell, whose thickness bears a very small proportion to the diameter of its sphere. But since an absolute void is inadmissible, the vast subterranean cavity must be filled with some very diffusive medium, of astonishing elasticity or internal repulsion among its molecules. The only fluid we know possessing that character is LIGHT itself, which when embodied constitutes *Elemental Heat or Fire*. The great concavity may thus be filled with the purest ethereal essence,—*Light* in its most concentrated state, shining with intense refulgence and overpowering splendour."[1]

It was the firm opinion of the ancients that our atmosphere rises as high as the Moon, the whole space below being doomed to change, decay, and mortality; and this notion still tinctures the language of poetry. But Kepler first reduced the extent of atmosphere within moderate limits. Astronomers having observed that twilight commonly closes after the sun has sunk 18 degrees below the horizon, it was hence easy to compute that the highest portion of air which from the west reflects the departing ray must have an altitude of about 44 miles. This conclusion, however, seems invalidated by the remark of Lambert, that twilight does not absolutely cease, but is succeeded during the night by a series of decreasing *crepuscles*, formed by a double, a triple, or even a quadruple reflection. These secondary lights may therefore be produced by the repeated gleaming from the sky at much lower elevations.

A wider limitation of the atmosphere is derived from a rigid principle. It is evident that the particles of air, as they expand from the axis of rotation, will augment their centrifugal tendencies, while their attraction to the centre will diminish in a duplicate ratio. At a certain distance, therefore, those antagonist forces will produce a mutual equilibrium. This balance must occur in the equatorial region at the height of 6·6 semidiameters, or about 26,000 miles, when the centrifugal force is increased, and the power of gravitation is reduced to about $\frac{1}{43\frac{1}{2}}$.

The late Dr Wollaston arrived at nearly a similar conclusion, from an hypothesis respecting the ultimate molecules of the atmosphere. But a different consideration will bring us within much narrower limits. If we assume the depression of the absolute zero to be 750 centesimal degrees, and adopt the *formula* already stated for the relation of the density and temperature of air, it will follow that the tenuity of the highest stratum of the atmosphere cannot exceed 50×750 or 37,500 times, which corresponds to an altitude of about $51\frac{1}{2}$ miles. This boundary nearly coincides with the approximation of Kepler, and likewise agrees sufficiently with the estimated range of the *Aurora Borealis*. It thus appears from concurring probabilities, that our atmosphere extends not above 50 miles, the higher regions perhaps being occupied by hydrogen gas transfused with phosphorescent matter.

The perfection of astronomical instruments has afforded the prospect of being able to determine the *Annual Parallax*, and consequently the distance of the fixed stars; but the quantity of deviation is so small as to have hitherto eluded the closest observation. It cannot amount to a single second in the most conspicuous and probably the nearest of the stars. These luminous bodies must therefore be more distant at least *two hundred thousand* times than the measure of the diameter of the earth. The light emitted from such neighbouring suns, though it flies with enormous rapidity, must yet travel more than six thousand years before it approaches the confines of our system.

But scattered over the immensity of space, there may exist bodies which, by their magnitude and predominant attraction, retain or recall the rays of light, and are lost in solitude and darkness. Had the celerity of the luminous particles not exceeded four hundred miles in a second, we should never have enjoyed the cheering beams of the Sun. They would have been arrested in their journey, and drawn back to their source, before they reached the orbit of Mercury. But a star similar to our Sun, and having a diameter 63 times greater, would entirely overpower the impetus of light.

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[1] *Elements of Natural Philosophy*, pp. 449–453.

Many of the smaller stars are found to have proper motions, some of them to an extent of several degrees. Mayer attempted to class the shifting stars according to their places in the heavens, and remarked that, while those situate in two opposite quarters appeared nearly stationary, such as had a lateral position varied the most. He therefore inferred that our Sun and the whole train of his attendants are carried forward in the line joining those opposite points. Herschel seized this ingenious idea, and combining his own observations, he concluded that the translation of the planetary system is directed to the constellation of Hercules. But the critical examination of Bessel has proved that no such regular transfer would reconcile the various discrepancies of the shifting stars.

The *Double* and *Multiple* Stars have lately engaged the attention of observers. Their catalogue has been prodigiously augmented by the ardour of South and the younger Herschel, and by the unwearied assiduity of Struve at Dorpat, and of Inghirami at Florence. The Double Stars assume every hue, but generally the contrasted or complementary colours; a circumstance which seems to betray the influence of ocular deception. Their proper motions result probably from a circulation around their common centre of gravity. The Multiple Stars may possibly derive their peculiar aberrations in certain cases from the revolution about huge invisible Suns. All these mutable Stars are extremely remote, descending so low as the twentieth degree of magnitude, and can therefore be distinguished only by the penetration of the most powerful telescopes. Imagination is utterly bewildered by the shadowy visions which flicker along the horizon of Illimitable Space. But each successive observation reveals more clearly the extension of that exquisite harmony which the great law of attraction maintains through the countless systems of Worlds.

END OF VOLUME FIRST.

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DISSERTATION SIXTH:

EXHIBITING A GENERAL VIEW

OF THE

PROGRESS OF MATHEMATICAL AND PHYSICAL SCIENCE,

PRINCIPALLY FROM 1775 TO 1850.

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DISSERTATION SIXTH.

MATHEMATICAL AND PHYSICAL SCIENCE.

CHAPTER I.

INTRODUCTORY.

§ 1. *On the Plan of this Dissertation.*

(1.) Modern Advances in Science. THE year 1850 may be said to complete the Third century of modern scientific progress, or the Fourth if we include its earliest dawn. To each of these ages of discovery may be assigned a peculiarity in the character of its improvements, and even in the methods which conduced to that improvement.

(2.) Period 1450-1550. Between 1450 and 1550 (a period so distinguished in letters and the arts), some great truths in physics and mathematics had presented themselves to a few precocious minds, yet they had not received any public acknowledgment, nor perhaps an adequate demonstration. Algebra then first became a science. Leonardo da Vinci made the earliest steps since the time of Archimedes, in rational mechanics, and Copernicus almost at the close of this period promulgated the true system of the world.

(3.) Period 1550-1650. But the next centenary (1550-1650) was the first of true scientific activity. Its characteristic feature was the vindication of observation and experiment as the prime essentials to the increase of natural knowledge, with the consequent repudiation of the dogmas of the schoolmen, and the baseless methods of *à priori* reasoning. The men of science formed a goodly array at this stirring time; and signal were their triumphs. Galileo was beyond all comparison the glory of his age. His sagacity, his knowledge, his versatility of talent, his ingenuity as an inventor, his success in prosecuting his discoveries, and his zeal and eloquence in making known their importance, gave him an enviable pre-eminence even amidst a mighty generation. Bacon laid down the canons of a new method in philosophy which Gilbert and Kepler, as well as Galileo, had already acted on. Napier and Descartes prepared for the general application of mathematics in the coming struggle.

(4.) Period 1650–1750. The hundred years which next succeeded (1650-1750) saw the triumphant application of mathematics to Mechanics and Physics, and the establishment of the greatest mechanical theory of any age, that of Gravitation. The preparatory labours of a hundred and fifty years were brought, chiefly by the unparalleled sagacity and genius of Newton, to a speedy and dazzling climax. His success brought numerous and worthy labourers into the field, but they found enough to do in gathering in the harvest which he had prepared for them.

(5.) Period 1750–1850. If we look for the distinguishing characteristic of the centenary period just elapsed (1750-1850), we find it in this,—that it has drawn far more largely upon Experiment as a means of arriving at truth than had previously been done. By a natural conversion of the process, the knowledge thus acquired has been applied with more freedom and boldness to the exigencies of mankind, and to the farther investigation of the secrets of nature. If we compare the now extensive subjects of Heat, Electricity, and Magnetism, with the mere rudiments of these sciences as understood in 1750, or if we think of the astonishing revival of physical and experimental Optics (which had well nigh slumbered for more than a century) during the too short lives of Young and Fresnel, we shall be disposed to admit the former part of the statement; and when we recollect that the same period has given birth to the steam-engine of Watt, with its application to shipping and railways,—to the gigantic telescopes of Herschel and Lord Rosse, wonderful as works of art as well as instruments of sublime discovery,—to the electric telegraph, and to the tubular bridge,—we shall be ready to grant the last part of the proposition, that science and art have been more indissolubly united than at any previous period.

(6.) Limits of this Dissertation.

The Dissertation of Professor Playfair closes with the period of Newton; that of Sir John Leslie, professedly devoted to the history of the eighteenth century, embraces some matters which belong more properly to those which preceded and followed it. After considering how I might best carry out the plan of these essays, I have adopted the period from about the year 1775 to 1850 as the general limit of my review. We may imagine this period, of three quarters of a century preceding the present time, to be divided into three lesser intervals of 25 years each, which have also some peculiar features of their own.

(7.) Character of the close of the 18th century.

From 1775 to 1800 many branches of science still continued in the comparatively inert state which characterized a great part of the eighteenth century. There were, however, two or three notable exceptions. One was the continued successful solution of the outstanding difficulties of the Theory of Gravity applied to the moon and planets, a task in which the continental mathematicians, and of these, in chief, Lagrange and Laplace, had no rivals, or even coadjutors, on this side of the channel: Another was the foundation of Sidereal Astronomy by Sir William Herschel; and the last was the commencement of a system of Chemical Philosophy based on new and important experiments, and including the laws of heat in combination with matter, which at that period very naturally ranged themselves within the province of the chemist. In this department two British and one foreign name stand conspicuous, Black, Cavendish, and Lavoisier. I do not of course mean to affirm that other branches of science were not cultivated with success within the exact period of which we speak. Electricity, for instance, first statical, afterwards that of the pile, had a share in the discoveries and speculations of the time. But these were rather the mere extension of what had previously been thought of; or the first dawn of future important results, whose development fills a large space in the succeeding story. Volta and his inventions belong rather to the nineteenth than to the eighteenth century.

(8.) Character of the period 1800–1825.

The first quarter of the present century attained a higher and more universal celebrity. Scarcely a branch of physical science but received important and even capital additions. Physical Astronomy indeed, no longer filled so large a space in the page of discovery, simply because the exhaustive labours of the geometers of the former period had brought it to a stage of perfection nearly co-ordinate with the means of observation, and because, by the publication of the *Mécanique Céleste*, Laplace had rendered available and precise the masses of scattered research accumulated by the labours of a century since the close of Newton's career of discovery. It was in some sense a new book of "Principia,"—not, indeed, the work of one, but of many; nor of a few years, but of two generations at least. Still there it was, a great monument of successful toil, which, like its prototype, was for many years to be studied, even by minds of the highest order, rather than to be enlarged.

Mécanique Céleste

(9.) Experimental Physics.

But the other branches of Natural Philosophy were now to make a stride, such as perhaps no preceding time had witnessed. The science of Optics was speedily expanded almost twofold, both in its facts and in its doctrines. Galvanic Electricity disclosed a series of phenomena not less brilliant and unexpected in themselves than important from the new light they threw on the still dawning science of chemistry, and from the power of the tool which they placed in the hands of philosophers. Before the first quarter of the present century closed, the important and long suspected connection between Electricity and Magnetism was revealed, and its immediate consequences had been traced out with almost unparalleled ingenuity and expedition. The basis of the science of Radiant Heat, slightly anticipated by the philosophers of the eighteenth and even the seventeenth centuries (Lambert and Mariotte), was finally laid in a distinct form, assigning to the agent, *heat*, an independent position dissociated from grosser matter, such as *light* had long enjoyed. Astronomy, though enriched on the very first night of the new century by the discovery of a small planet, the herald of so many more of the same class, made perhaps less signal progress; but Chemistry, besides the aid it received from the invention of the pile, had a triumph peculiarly its own in the addition of the comprehensive doctrine of Definite Proportions, destined to throw at some later time a steady light on the vexed question of the constitution of matter. The great number of scientific names of the first order of merit concerned in these numerous discoveries marks the extraordinary fertility of the period. They are imperfectly comprehended in the following list: Young, Malus, Sir David Brewster, Fresnel, and Arago; Volta, Dalton, Davy, and Oersted; Prevost, Leslie, and Fourier; Gauss, Ivory, Olbers, Bessel, and Encke.

(10.) Period 1825–1850.

Of the twenty-five years just elapsed, it is not so easy to speak with precision. The voice of criticism may be fairly uttered with that reserve which every one must feel in speaking of his immediate contemporaries. Yet it may perhaps be stated without just cause either of offence or regret, that it has not on the whole been characterized by the full maturity of so many commanding minds. Of the great discoverers of the former period, several survived and continued their efficient labours during no small portion of the latter; and a few happily still remain to claim the respect and veneration of their disciples and successors. But the vast steps so recently made in Optics, in Electricity, in Magnetism, in Thermotics, and in Chemical principles, tended of necessity to call forth such an amount of laborious detail in the defining and connecting of facts and laws, and the deductions of the theories started to explain them, as seemed to render fresh and striking originality somewhat hopeless, whilst they occasioned a vast amount of useful employment to minds of every order of talent. Optics. The undulatory Theory of Light, nobly blocked out by the massive labours of Young and Fresnel, has afforded still unexhausted material to the mathematician on the one hand, and to the experimentalist on the other; and ably have they fulfilled the double task, adding at the same time discoveries whose importance and difficulty would have made them still more prominent, had they not been the legitimate consequences of a still greater discovery already in our possession. Nearly the same might have been said for the sciences of Electricity, Electro-magnetism, and Electro-chemistry, had not the comparative newness of the whole doctrine of these sciences, and the suddenness of their first rise, and, perhaps still more, the appearance of a philosopher of the very highest merit, Mr Faraday, who fortunately attached himself to this special department, made the last thirty years an almost unbroken period of discovery. Electricity. Heat. Radiant Heat, too, has been successfully advanced by labours comparable perhaps to those which marked its first rise as a science, and some other topics connected with heat have risen into great and practical consequence. Astronomy. Astronomy has been prosecuted with a systematic assiduity and success, especially at the British and Russian national observatories, which yields to that of no former period, whilst physical astronomy has been cultivated by methods of still improved analysis, and has achieved one triumph which France need not grudge to England, nor England to France,—so signal as to be placed by common consent in a position superior to any since the first publication of the theory of gravitation, more than a century and a half before. This was the prediction of the position in space of a planet whose existence was unknown except by the disturbance which it produced in the movements of another. Magnetism. Terrestrial Magnetism has, for the first time, aspired to the rank of an exact science. In an illustrious philosopher of Germany, it has found its Kepler; and the combination of national efforts in collecting reliable data from the remotest corners of the globe is characteristic of the practical energy of the age. Chemistry. Pure Chemistry has been cultivated with extraordinary assiduity; but though some general principles have emerged, none are comparable, from their importance, to the discovery of Dalton. To cite, then, at present, but a few names, amongst the most conspicuous benefactors of science of the last, or contemporary period, are MM. Airy, Cauchy, Hamilton, and MacCullagh; MM. Faraday, Melloni, and Gauss; Sir John Herschel, M. Struve, and Lord Rosse; MM. Plana, Poisson, Leverrier, and Adams; MM. Mitscherlich, Liebig, and Dumas.

(11.) Mechanical arts.

It seems to me impossible to exclude from a review, however slight, of contemporary progress in the exact sciences, the advances which have accrued to them both directly, and, as it were, reflexively, by the astonishing progress of the Mechanical Arts. The causes, indeed, which called them forth are somewhat different from those which are active in more abstract, though scarcely more difficult, studies. Increasing national wealth, numbers, and enterprise, are stimulants unlike the laurels, or even the golden medals of academies, and the quiet applause of a few studious men. But the result is not less real, and the advance of knowledge scarcely more indirect. The masterpieces of civil engineering—the Steam Engine, the Locomotive Engine, and the Tubular Bridge—are only experiments on the powers of nature on a gigantic scale, and are not to be compassed without inductive skill as remarkable and as truly philosophic as any effort which the man of science exerts, save only the origination of great theories, of which one or two in a hundred years may be considered as a liberal allowance. Whilst then we claim for Watt a place amongst the eminent contributors to the progress of science in the eighteenth century, we must reserve a similar one for the Stephensons and the Brunels of the present: and whilst we are proud of the changes wrought by the increase of knowledge during the last twenty-five years on the face of society, we must recollect that these very changes, and the inventions which have occasioned them, have stamped perhaps the most characteristic feature—its intense practicalness—on the science itself of the same period.

(12.) Review of the History of Science in this Essay.

Having thus briefly reviewed the course of discovery since the latter portion of the eighteenth century, I proceed in the succeeding chapters to attempt to sketch it more in detail, dividing the sciences into groups, and in each of these endeavouring to present a lively view of its progress by connecting it with the individnal career of the eminent men who have most contributed thereto, and introducing collaterally the chief results obtained by their contemporaries. In this manner I hope, on the one hand, to escape the formality of a history of science, and the meagre detail which our limits would prescribe to so vast a subject; and on the other to be enabled to impress upon the reader (as seems to be the design of these Essays) the leading facts and features of discovery in every age, together with the intellectual characteristics of the greatest minds which contributed to it.

It is with no overweening confidence that I lay the (13.)

Scheme of treatment of the subject.

result of this attempt before the reader. During the lengthened period of composition of this Dissertation—protracted by indisposition and untoward circumstances of different kinds, I have had abundant leisure to reflect on the advantages and disadvantages of a plan which I had sketched in the previous paragraphs, at the very opening of my task. I am aware that a rigid criticism awaits every attempt like the present. I am aware also, that it is far easier to detect real faults, especially of omission, than to make sufficient allowance for the exceeding difficulty and delicacy of the undertaking. I have but one ground of confidence, and that is so strong, that I trust it will enable me calmly to meet every just critical reflection. I am conscious of having written in a spirit of absolute impartiality whether as regards persons or subjects, and that I have exercised to the full amount of my opportunities what powers of judgment I possess. I have striven to speak judicially and historically whether of friend or stranger, the dead or the living, Englishman or Foreigner. What I have felt the most constant effort, has been the needful exclusion of meritorious names, far more numerous than those especially included and dwelt upon in these pages. But this has appeared to me the cardinal point of my whole plan. The labourers in science have been in these latter days so numerous, that had I noticed, even briefly, every one who had made a real step in science, my pages must have been crowded by names and titles of books. Even with the extension of bulk to which this essay has gradually and unavoidably grown (nearly double of its projected amount), the reader would rather have been bewildered than led by the perusal of such a catalogue. Besides, since such a brief historical synopsis forms very generally an introduction to the several articles of the Encyclopædia, to repeat it all here would have been but a tedious redundancy. No one conversant with such matters will imagine that I have saved myself any labour by this particularity of selection. On the contrary, it would have cost no effort to enumerate under each subject the living or recently deceased authors upon it who are best known; such a detail must have left a vague and shadowy impression on the mind of the general reader, and when regard is paid to the necessary limits of the essay, and the multitude of technical details and technical words which there is no space to define and illustrate, it is plain that the perusal must have been rendered as dry and unpalatable to those who seek general and elementary yet clear ideas, as it would have been tantalizing and unsatisfactory to the accomplished student, or to the man of science in search of particular historical details.

(14.) The end at which I have aimed is to select the more striking land-marks of progress in each subject in each age, and endeavour to connect them with the character and position of all the more eminent discoverers, thus conveying to the general reader sufficient information on the limited number of particular subjects discussed, and interesting him not only in the science but in the individuals. Then, by a few slighter touches only, and the mention of some secondary names, to connect with one another these brighter periods of eminent progress, in which every country and every age feels a just pride.

(15.) That by many I shall be considered to have dwelt too much on some eras of invention, and to have omitted others not less important, is a difference of judgment which it is impossible not to anticipate, but equally impossible to prevent. I will only add that I have endeavoured to extend my impartiality to *subjects* as well as to persons; and that I have not intentionally dwelt longer on the topics of my own predilection than on those naturally considered by other persons equally or more important. Many subjects as well as persons familiarly known to me are scarcely, if at all, mentioned in these pages. To leave some definite and vivid impressions, selected solely for their importance, on the mind of my reader, has been the great object constantly before me during the composition of this work.

(16.) Compared with that of the preceding Dissertations.

It will be seen from the preceding paragraphs, that I have deviated in some respects from the scheme of my two distinguished predecessors in the composition of the Dissertations on Science, Professor Playfair and Sir John Leslie. The essay of the former, which is the more finished and methodical, is admirably adapted to the period of the history of science of which he had principally to treat; the period, namely, of Galileo, Bacon, Newton, and Leibnitz. But the amount of material was smaller, and the principle of selection was also much simpler. The positive science of that age might almost be reduced to two heads, Astronomy, including its mechanical principles, and Optics. It was an age not more distinguished for the Truths it disclosed, than for the invention and right appreciation of the Methods of Discovery. Inductive Logic, and Mathematical Logic applied for the first time to dynamics, very justly claimed a place in a dissertation on the progress of science, in a period when these preliminary doctrines and discoveries were the stepping stones by which even the basement story of the Temple of Nature could alone be reached. The Philosophy of Bacon and the discovery of Fluxions, occupied therefore, with much reason, a large portion of Professor Playfair's beautiful Dissertation; and it is impossible to regret that an intellect so admirably qualified for tracing and displaying the intimate and historical connection of branches of knowledge so varied in their principles and character, should have been thus congenially employed, to the delight and edification of readers of every degree of acquirement from the highest to the humblest.[1]

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[1] In mentioning the name of my distinguished predecessor in the Chair of Natural Philosophy in the University of Edinburgh, I willingly take the opportunity of noticing, in a few words, his peculiar merits, to which the Dissertation contained in

(17.) Extent and variety of materials.

But the extended domain of the science of the last hundred years enhances vastly the difficulty of the subjects succinctly handled as one by Mr Playfair. The mechanical and experimental sciences alone constitute a body of knowledge so large that it is a responsibility sufficient for one person to attempt to grasp them all, and to set forth in order the steps of progress and improvement which have been so rapid, and even so startling. Since some of these have scarcely as yet been historically digested, and the broad features of contemporary discovery have not been gradually separated by the judgment of an impartial posterity from those slighter though praiseworthy details, which lapse of time and advance of knowledge will throw into the shadows of distance,—this difficult and most laborious task falls principally upon the reviewer. The length and breadth of the subject of Natural Philosophy, and the cumbrous and scattered depositories of knowledge in which its records must be sought, combine to render not only the undertaking an arduous one, but the result of it a good deal more bulky than might be desired, or than was easily possible, in dealing with the glorious, but compact, history of Newton's age. It might be compared to the difference between writing a history of the Jews or Romans and that of the whole of modern Europe.

(18.) Logic of induction.

The mere magnitude of the undertaking, then, might well excuse me from entering upon the cognate, but exceedingly distinct, subjects of the Logic of Inductive Discovery and the progress of the Pure Mathematics. But an equally sound reason might be found in my consciousness of inadequacy to undertake, whatever had been the dimensions of my work, a threefold scheme of such magnitude and difficulty. I do not think that any one person could be found to treat the whole as it ought to be treated, and I am certain that I am not that person.

(19.) Writings of Dr Whewell and Mr Stuart Mill.

One attempt—a bold and successful one—has been made, in our own day, to unite two of the three departments,—I mean the History and the Philosophy of the Inductive Sciences. An English philosopher of wonderful versatility, industry, and power has erected a permanent monument to his reputation in a voluminous work bearing the preceding title.[1] A slight inspection of that work will show how impracticable and self-destructive a plan it would have been to attempt anything like a systematic abridgment of such a mass of facts and speculations within our present limits. Mr J. Stuart Mill has also published a work bearing on the origin of our scientific knowledge, diametrically opposed in principle to the preceding one, yet marked by great ability.[2] Such disquisitions belong more properly to the philosophy of the human mind than of physics. After all, be it remembered that whatever has been learnt or discussed concerning the means of arriving at truth in Natural Science, it is not pretended that we have recently become possessed of any canons or rules of discovery superseding those fundamental principles of observation and experiment so well laid down by Bacon, and practised both

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Character of Professor Playfair.

the present volume will bear an enduring testimony. Playfair's *original* contributions to science were not so marked and considerable as to justify me in including his name in the comparatively brief catalogue of discoverers chronicled in the succeeding pages; but his efforts are, nevertheless, deserving of notice, and indirectly were perhaps hardly less beneficial. He was a most patient and admiring student of the greatest mathematical writers of his time, and, when we consider the singularly backward state of that science in Great Britain about the end of the last and commencement of the present century, it was of no slight importance to find a man placed in the position of a public instructor able and willing to direct attention to the splendid achievements of the continental mathematicians. By his lectures both on Mathematics and Natural Philosophy—by his luminous articles in the *Edinburgh Review*—by some of his original papers in the *Transactions of the Royal Society of Edinburgh*—he contributed to this useful end, and would have done so still farther had he been enabled to complete the Dissertation which he so ably commenced. He had an excellent mathematical capacity, and mathematical *taste*, rather than *power*. His explanations, even of matters of inherent difficulty, are perspicuous and popular, qualities possessed by few of his contemporaries. His style has been pronounced by the highest authorities to be a model of clearness and eloquence. He was extensively read in subjects of metaphysics and morals, as well as of pure science; and by a combination of talent rare, I am inclined to say, in a high degree, his taste, though eminently mathematical, was also directed, with signal success (at first through his intimate friendship for Dr Hutton), to the very opposite studies of Geology and Physical Geography, which may be said to have been the subjects of his predilection during the last twenty years of his life. Nor were these labours of the closet merely; he was far more intimately versed in the mineral structure of the earth, from observation, than any except a few professed geologists; and he exceeded them all in the ability with which he expounded and maintained the striking doctrines of the Huttonian theory. Though professedly the "illustrator" of the principles specifically but obscurely laid down by Hutton, he certainly added much of his own. There is no reason to doubt that Playfair first apprehended the moving power of glaciers as geological agents in modifying the surface of Alpine countries, a matter which has of late been so earnestly discussed by the ablest geologists.

What adds to the singularity of the combination of tastes and talents to which I have referred is, that he appears to have had the slightest possible taste for that art of experiment which he eloquently advocated, with Bacon, as the grand distinction of modern science. I may be wrong in stating it broadly, but I do not now recollect a single experimental novelty, much less discovery, which we owe to Playfair, I mean in the department of Natural Philosophy; for we cannot include barometrical measurements under this head, of which, indeed, it was the mathematical theory, and not the application to practice, which chiefly occupied him. The same was the case in Astronomy, which, of the mechanical sciences, interested him most. In two capacities he will be remembered,—first, as the able, eloquent, and generally impartial and accurate Historian of Science; secondly, as the promoter, to so great a degree as to be considered a second founder, of modern Dynamical Geology. He was much beloved in private life, and was singularly free from the tendency to carping criticism and personal prejudices sometimes, unfortunately, found in men of letters. He was the intimate associate of Jeffrey and the other founders of the Edinburgh Review. His character has been drawn in three words by Sir James Mackintosh, and as happily contrasted with that of his illustrious friend:—" . . . . Playfair and Jeffrey; the first a person very remarkable for understanding, calmness, and simplicity, the second more lively, fertile, and brilliant than any Scotchman of letters" (*Life of Sir James Mackintosh*, ii. 251).

[1] Whewell's *History and Philosophy of the Inductive Sciences*, 5 vols. 8vo.

[2] Mill's *Logic*, 2 vols. 8vo.

before him and since by Galileo, Newton, and their disciples.

(20.) Pure mathematics—their progress and technicality.

With regard to Pure Mathematics, and their progress during the last seventy years, to the difficulty arising from the extent to which the review must have enlarged this Essay, and the enormous and disproportionate labour it must have cost (a labour far greater to the present writer than to one by taste and habit more addicted to the study of merely abstract Analysis), a conclusive argument against their *systematic* introduction into this historical sketch is to be found in the very nature of these modern improvements. All sciences—but especially the abstract sciences—tend to become more intensely technical the farther they are pursued. These especially are incapable of popular treatment, although in their applications to physical science they occasionally admit of it in a very remarkable manner. The progress of analysis cannot be even enunciated or expressed but in the language of analysis, and the History becomes almost a Treatise, or, if not a Treatise, something nearly as technical. It is partly for this reason that the history of the Pure Mathematics has so seldom been even attempted to be written.[1] Mathematicians have, since the time of D'Alembert, been noted for being more ready themselves to publish than to become acquainted with what others have done; and one consequence of this has been the formation of a mathematical literature, able, profound, and original, but cumbrous, fragmentary, and full of repetitions.[2] Besides, the seventeenth century had attained the vantage-ground of those grand and striking improvements in methods to which no subsequent improvements, however real and ingenious, can by possibility compare. We shall never have inventions comparable, in universality and importance, to the application of Algebra to Geometry, and the discovery of Fluxions. These also admit of being at least partly explained in language not obtrusively technical, and have been so explained by the facile pen of Playfair; but all subsequent discoveries have been but enlargements and improvements on these primary and distinguishing ones; and before the date at which our present discourse properly opens, even the larger generalizations of Newton's fertile calculus—the method, namely, of Variations, and the integration of partial differential equations, had been established, by the genius of Euler and Lagrange, on an impregnable basis.

(21.) The intense, and praiseworthy, and successful labours of their followers have been, then, chiefly devoted to the occupation of the fields of conquest thus summarily opened; or, rather, to storming, one by one, fortresses still unreduced, after the main resisting army had been first routed in the open field. To quit metaphor, the efforts of mathematicians have for many years been chiefly applied to rendering possible the solution of problems involving quantities which actually occurred in the course of the rapid simultaneous advances of physical science. They are in a manner inseparable from the branches of physics in aid of which they were originally called forth, and will therefore be most properly noticed, however briefly, in the chapters of this Dissertation where their application is considered. Some farther observations on this subject will be found in the immediately succeeding section of the present Essay.

(22.) Subdivision of Physico-Mathematical Sciences.

In reviewing the progress of science—physical science in particular—during the last seventy or eighty years, I have thought it advisable not to subdivide the subjects too minutely, and, following nearly the arrangements of Dr Whewell's excellent treatise, already quoted,[3] I shall treat, in successive chapters, of Analytical Mechanics including Physical Astronomy as their loftiest and most successful application; of Astronomy as a science of observation; of Mechanics, with reference to the intimate constitution of matter, including Hydrodynamics, Acoustics, and Civil Engineering; of Optics, or Light; of Heat, including the Daltonian theory of the gases and chemical elements; and, finally, of the large and comprehensive science of Electro-magnetism, including ordinary and Voltaic Electricity, Terrestrial Magnetism, and Diamagnetism the discovery of Dr Faraday.

(23.) Arrangement partly methodical, partly biographical.

The arrangement of the chapters is thus strictly Methodical; but in the subdivision into sections, I have allowed the Biographical principle to predominate, thus giving as much as possible a historical character to the whole, and endeavouring to introduce the reader to the intellectual acquaintance of the eminent men who are selected for notice on the principles which have been already detailed. In some instances, however, it has been necessary to introduce the same individual into two or three different sections, and even into different chapters, when his pursuits have been in very various branches of science. This has been avoided, however, as much as possible, and a sacrifice has occasionally been made of the methodical order of the subjects, so as to combine in one view all that has made an eminent philosopher illustrious. Such little sacrifices of arrangement are incidental to the way of treating the whole subject; and it may be hoped that its practical advantages, in the eye of the general reader, will be found to compensate for its defects as they may appear to the more rigorous student. For the sake of the latter especially, a short but comprehensive index of Names and Terms is prefixed, by which, I believe, it will be easy to trace all that is said of any one person or subject in any of the chapters.[1]

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[1] Specimens of what a history of pure mathematics would be, and must be, are to be found in the able "Reports" of Dr Peacock and Mr Leslie Ellis, in the Transactions of the British Association for 1833 and for 1846. A glance at these profound and very technical essays will show the impossibility of a popular mode of treatment, whilst the difficulty and labour of producing such summaries may be argued from their exceeding rarity in this or any other language.

[2] The celebrated Lagrange, in his later years, contrasting the mathematical works of his own generation with those which he studied when a youth, is said to have observed :—"I pity the young mathematicians who have so many theories to wade through. If I were to begin, I would not study; these large quartos frighten me too much."—(Thomson's *Annals*, vol. iv.) And it is stated that whilst his own most abstruse investigations were conducted in Paris, he kept the perusal of M. Gauss's writings for the tranquil retirement of the country,—a distinction intelligible enough between the intense effort of invention more than sustained by the *vis viva* of genius which prompts it, and the strain required to master the dead weight of reasoning imposed upon the mind by the discoveries of another. Dr Young, in his biography of Lagrange, observes upon the voluminous mathematical literature of his time, that "unless something be done to check the useless accumulation of weighty materials, the fabric of science will sink in a few ages under its own insupportable bulk." The fact is that a large proportion of the mathematical writings of even eminent authors are in a few years forgotten, or only casually consulted on some matter of history.

[3] *History and Philosophy of the Inductive Sciences.*

§ 2. *On the relations between Mathematics and Natural Philosophy, and between the latter and the Mechanical Arts.*

(24.) Connection of Mathematics, physics, and mechanical arts.

The object of this Dissertation has little in common with an attempt formally to subdivide human knowledge into compartments, and to assign their boundaries with metaphysical exactness. It is chiefly in their practical bearing on one another that they must be considered. If one science, like Mathematics, furnish the only sure step towards the understanding or the enlargement of another, as Astronomy or Optics, a practical link is constructed between them, which renders the progress of the one not independent of the progress of the other. The intimate and reciprocal connection thus subsisting between Mathematics and Physics is to be found in almost an equal degree between Pure Physics and the Mechanical Arts, of which we take Civil Engineering to represent the department most cognate to that of Natural Philosophy, of which this Dissertation more especially treats.

(25.) Boundaries of Science and Art undefined.

The history of the last seventy or eighty years enforces this conclusion. The boundaries of Science and Art are as undefinable as those of "fact" and "theory," or those which separate the kingdoms of nature from one another. There are arts which can hardly be called scientific, and there are others which have contributed more to the original stock of knowledge than they ever drew from it. These last are like the shoots of those tropical plants which at first are mere buds upon the trunk, and are nourished solely by its juices, but which, when they reach the ground, plant themselves there, and become not only the props and stays of the parent stem, but supply it from an ever-increasing area with the sap which they originally borrowed.

(26.) The more closely we examine the subject, the more are we satisfied that it is impossible to teach science rightly without teaching its applications; and that the limit to which we are to do so is a limit depending solely on the judgment of the teacher, and on the special purpose of the lesson. But the progress of science is a lesson learnt from the great book of experience; and if we are to feel the force of its teachings, we must consult, not one, but many of its pages. Looking to the history of science since 1750, but especially during the present century, it is quite impossible not to admit how large a share the sciences of application have had in moulding the direction of men's thoughts and speculations, and in enabling, nay, compelling them to realize certain abstract notions far from easy of conception. Instances of this are to be found in the force of percussion, the coexistence of vibrations in air and other substances, and such notions of *body* as we derive from practical efforts of continually-increasing boldness to extend the scale of our constructions.

(27.) Practical character of the last 100 years.

The analogy of the relation between Mathematics and Physics, and of the latter to civil Engineering, is so close that the three subjects might almost be represented as three terms of a continued proportion. What the second is to the first may be affirmed of the third relatively to the second. Physics may exist, at least to a limited extent, without a mathematical basis, as the art of construction long preceded a knowledge of the principles on which it is founded. But as knowledge advances it extends in both directions towards speculation and towards practical applications, but most towards the applications. This Bacon well understood, and he has consistently maintained, that knowledge, to be profitable to its cultivators, must also be fruitful to mankind. And all the history of science since Bacon's day has read this lesson more and more loudly in the ears of mankind. The era of Newton and Leibnitz was grandly distinguished by the continually increasing applications of mathematics to physics, whereof Newton was the great teacher; the century 1750–1850, whilst profiting by the lessons of the past, has added almost a new one in the eminently practical character of its science, and in the no less scientific character of its practice. The result of these gradual modifications of human knowledge has not been in the slightest degree injurious to the real progress of the more abstract ingredient of the mixed sciences. Did mathematics ever flourish more vigorously than under Newton? has pure physical science had greater triumphs than in the era of Volta, Watt, and Young? It was precisely because the new application of mathematics stimulated their growth, because abstract relations of quantity were vivified by concrete solutions of physical problems, that a new geometry arose. Dynamics could hardly be said to exist as a science without the invention of Fluxions as a language by which its conditions and results might be expressed; and from that time onwards, the necessities of the natural philosopher have been the prime sources of inspiration to the geometer, while the subjects have become so blended that a *mere* discoverer in mathematics has become a singularity. It would be hardly possible to point out any mathematician of the highest class since Newton, or but a few of the second class, who have not contributed almost as much to physical science as they have to analysis. Of purely mathematical discoveries, the great majority have been called forth by the immediate necessity arising from some problem requiring solution in astronomy, mechanics, optics, or heat. Lagrange's method of Variations of arbitrary Constants in Integration, the artifices for the computation of attractions by Laplace's coefficients; the introduction of the method of factorials by Kramp in his solution of the problem of refraction, and numberless improvements in the Theory of Definite Integrals by Fourier and his successors, sufficiently warrant the statement, and show how richly the physical sciences have repaid to the purely mathematical ones the debt which they originally owed. One other conclusion may be drawn from these and parallel facts. It is that the combinations arising out of external phenomena are more suggestive of the possible relations of number and quantity than is the most unlimited stretch of fancy and imagination; and I believe it will be conceded that, with few exceptions, theorems of the greatest value and beauty have been more frequently discovered during the attempt to solve some physical or at least geometrical problem, than in comprehensive yet indefinite attempts to generalize the relations of abstract magnitude.

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[1] I have borrowed but sparingly, in the following pages, from the existing compilations on the history of science. Indeed, a writer who intends to make a subject his own by a well-considered, fundamental plan of treating it, will use such works principally as a guide to his own further inquiries, and to assist him in selecting the topics worthy of fullest discussion. In this respect Dr Whewell's excellent writings, already cited, have been of great use to me; and in the particular department of Astronomy, I have often referred to Mr Grant's valuable History of that science, as well as to the writings of Delambre, and the very elaborate Historical Essay by M. Gautier, on the problem of the Three Bodies, which is not, I think, noticed by Mr Grant, but which contains a most elaborate history of the researches of Lagrange and Laplace. In optics, I have consulted the systematic treatises of Dr Young, Sir D. Brewster, Sir J. Herschel, Dr Lloyd, M. Moigno, and M. Radicke; and so of other subjects. Gehler's *Physikalisches Worterbuch*, Fechner's *Repertorium*, and that of Dove, afford a vast amount of historical information. The Transactions and Proceedings of the various societies, British and Foreign, have of course furnished a great part of my information. Such strictly biographical details as I have made use of, have in general been very carefully taken from the best accessible authority.

Not injurious to abstract science.

(28.) These views are strikingly confirmed by the historical fact of the paucity of *pure* mathematicians, and of distinct mathematical treatises of a strictly original character in an age distinguished by the diffusion of mathematical knowledge, and in countries (like France) most celebrated for its triumphs. There are not, perhaps, much more than half a dozen really great mathematicians of the last seventy years, who have not left treatises more numerous and more distinguished on physical science, treated mathematically, than on pure mathematics. Among the exceptions which more immediately occur, are Monge, Legendre, and Abel. And of distinct treatises, whilst we have the *Mécanique Analytique*, the *Mécanique Céleste*, the *Théorie de la Chaleur*, and numberless others, containing precious mathematical developments, in connection with the applications which suggested them, the purely mathematical memoirs of the same period are to be sought chiefly in the form of detached essays, in the ponderous volumes of Academical Transactions.

The pure Mathematics.

(29.) One point in the History of Mathematics has especial interest for the English reader, and as such may be touched upon here with reference to the progress of science for the last three quarters of a century. The national pride of England in the triumphs of Newton impelled her ablest mathematicians to attempt to carry forward the synthetic methods which he had chiefly used, at least in his published works, to the more arduous and intricate questions of Mechanics and Astronomy which presented themselves for solution in the course of the 18th century. Maclaurin was almost the last Englishman of that period whose mathematical writings came into direct competition with the rising schools of Germany and France. The labours of Matthew Stewart, and Simpson were mostly geometrical; those of Landen and Waring, though profound, created little general impression; and, gradually, the extent and difficulty of the foreign mathematics, increased by the use of the Leibnitzian notation of differentials which was absolutely unfamiliar in England, deterred almost every one even from perusing the writings of Clairaut and D'Alembert, Lagrange and Laplace. Of the continental mathematicians, Euler was probably the best known, owing to the lucidity of his writings and their eminently practical tendencies. Some idea may be formed of the negation of mathematical talent in Britain during the later portion of the last century, when we find D'Alembert declaring, in 1769, that if an Englishman is to be elected one of the eight foreign associates of the Academy of Sciences, he will vote for Earl Stanhope as the best mathematician there, as he believes, not having read any of his works! If the choice was to be free, he should prefer M. de Lagrange!![1] A more cutting, though unintentional satire on the state of Mathematics in this country could not have been written.

Their progress in this country.

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[1] Letters of eminent persons, addressed to David Hume, edited by Mr Burton, p. 215.

(30.) At Cambridge, Edinburgh, and Dublin. The commencement of a better era originated, early in the present century, with Woodhouse at Cambridge, and Playfair in Edinburgh, by both of whom the continental methods were introduced into the studies of their respective universities; whilst Ivory, a native of Scotland, was the first to challenge, by his writings, a place in the list of great living mathematicians. The systematic form of the *Mécanique Céleste* rendered the subject more accessible than were the countless memoirs by men of the highest name, which then filled the Transactions of Paris, Turin, Berlin, and St Petersburg. But the notation of differentials, which could alone break down the barrier between the British and foreign mathematicians, was first introduced at Cambridge by the efforts of Sir John Herschel and Dean Peacock about 1816, soon after which the translation of Lacroix's *Differential Calculus*, which they superintended, came into use as an university textbook. From this time the works of foreign mathematicians began to be more generally read, particularly the writings of Laplace and Poisson; and within ten or a dozen years subsequently, a few active and undaunted men, chiefly of the Cambridge school, such as Mr Airy and Sir John Lubbock, grappled with the outstanding difficulties of physical astronomy, whilst a larger number applied themselves to the most difficult parts of pure analysis, and acquired great dexterity in its use in the solution of geometrical and mechanical problems. Such, for example, were Mr Babbage, Mr De Morgan, Mr Murphy, and Mr Green; and at Dublin Sir William R. Hamilton and Mr MacCullagh, whose names will occur in other parts of this Dissertation.

(31.) Improvements in Integration. No new calculus or great general method in analysis has resulted from these persevering labours, whether of British or foreign mathematicians, but an increased facility and power in applying the existing resources of mathematics to the solution of large classes of problems previously intractable, or resolved only indirectly or by approximation. The Integral Calculus, in particular, affords an almost boundless field for research, and each branch of science in succession—not only Physical Astronomy, but Optics, Heat, Electricity, and Civil Engineering—has offered problems of great importance, which awaited only the skill of the pure mathematician to resolve in a practical and finite form.[1] Every year, and every civilized community, contribute to these real Discontinu- us func- ions. improvements. The principle of *discontinuity*, conspicuously introduced into the doctrine of the conduction of Heat in consequence of the abrupt variation of physical circumstances at the boundary of the conducting body, enters largely into the speculations of mathematicians of the present century; and the doctrine of definite integrals so intimately connected with it has received a proportional extension. Analytical geometry. Next, analytical geometry has acquired a very great enlargement and by attention principally to symmetry in the arrangement of the results, solutions otherwise the most intricate are obtained with facility and directness. Of this we shall find examples in our history of the Undulatory Theory of Light. The Calculus of Operations. Lastly, notwithstanding the pre-eminently practical character of the mathematics of the last age, speculative geometers and analysts have found time to discuss the metaphysics of their respective sciences, both as regards the foundations of the Differential Calculus and as to the use of imaginary and other symbols in Algebra. An almost new branch of abstract science (though faintly foreshadowed by Leibnitz) has come into existence—the separation of symbols of *operation* from symbols of *quantity*, and the treatment of the former like ordinary algebraic magnitudes. In some cases remarkable simplicity is thus introduced into the solution of problems, although perhaps few mathematicians would choose to depend implicitly upon the method in untried cases. Sir John Herschel and the late Mr Gregory[2] were amongst the most active introducers of this new algebra, but few of the more eminent living British or foreign mathematicians have failed to contribute their share to this more metaphysical department of analysis.

(32.) Connection of physical science and the arts. I shall now attempt to consider more particularly the reciprocal relations of pure physical science and the mechanical arts.

(33.) This is evidently a very intimate one. The discoveries of pure physics (such as Astronomy, Acoustics, Magnetism), are the results of either observation or experiment, and they consist in generalizations, by means of which a multitude of facts are reduced under one simple expression of a more general fact or principle. But instruments often very complicated are necessary for observation and for experiment; as telescopes in astronomy, organs in acoustics, properly magnetized and suspended steel bars in magnetism. Art is required to construct these. The highest possible degree of science, and the utmost mechanical skill, are both indispensable to make a telescope. A telescope then, though a mechanical invention, inasmuch as it is a deduction from physical principles, not an addition to them, is yet a deduction so ingenious—so far from obvious—so impossible to be conceived accidentally or by a loose thinker, and so easily made the instrument of innumerable discoveries of the highest novelty and grandeur, that no historian of science ever thought of omitting the invention of the telescope, or of giving it an importance inferior to that of a discovery, containing as it did the germ of so many discoveries. In like manner a theory of optics might be written in which a telescope need never be mentioned; but would not the pedantry of such a work be obvious, or would any reasonable person wish to learn science after such a fashion?

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[1] For example the Lucasian Professor at Cambridge, Mr Stokes, has effected two previously impracticable integrations, one occurring in the theory of the rainbow, the other in that of railway girder bridges.

[2] Mr Duncan Gregory. Mr Duncan Gregory, a promising mathematician who died 23d February 1844, at the early age of 30, was the youngest son of Dr James Gregory, the late distinguished Professor of Medicine at Edinburgh. His name deserves a passing record, not only from the influence he exercised on the progress of the English mathematics of his time, but as having revived the dormant character for this peculiar kind of talent, so long connected with the family of Gregory. He was, in fact, the lineal descendant of the inventor of the reflecting telescope. Mr Gregory was the first editor of the Cambridge Mathematical Journal, and author of an excellent book of Examples in the Differential and Integral Calculus, both of which have exercised a beneficial influence on the progress of science in England. He also wrote several original memoirs on the subjects referred to in the text. Mr Leslie Ellis, a man of congenial ability, has written a short but pleasing biography of his friend.

(34.) Great Mechanical inventions presume a knowledge of physical laws;

The clear co-ordination of the parts of an invention towards the attainment of a given result, with a due regard to natural laws, and the properties of the substances used, constitutes the merit of the invention; and this merit may be irrespective of the precise importance of the end of the invention, which may be intended to promote science, or commerce, or convenience, or even to satisfy mere curiosity. A telescope would have been a telescope still, could we have imagined it invented with no other object than a deerstalker's sport; and so contrivances which in their origin and application seem remote from scientific uses, constitute nevertheless real steps in the progress of knowledge. The steam-engine is one striking example. Originally devised with an exclusively commercial object—the extrication of the Cornish mines from subterranean water, it became in the hands of Watt, first an instrument for experiments on the relation of heat to matter; next, in its improved form, a beautiful exemplification of these laws, and an enduring monument of the sagacity and skill of its author, as well as the most important inorganic agent which exists in modifying the social condition of the entire globe. Finally, to illustrate the position from which we started, it becomes the instrument of fresh discoveries. This very engine has a theory to be worked out, probably unimagined even by its sagacious author—its operation as an agent for obtaining power from matter by the application of heat, is shown to be in all probability a single case of a more general law, including all kinds of machines and all sorts of matter; and this more general theory of heat as a motive power leads, once more, to new practical deductions, to the conditions under which such machines may be most usefully constructed and employed.[1]

(35.) and generally an inductive process.

Every instrument, every construction, which is founded on a theory, and in which a certain complication of conditions is required to produce a certain result; a telescope, for example, or a steam-engine, or a bridge, is, in the first instance at least, an experiment. Few inventions are so simple and straightforward in their plan, are so independent of the seemingly capricious behaviour of matter under untried circumstances, or depend so entirely on physical laws thoroughly understood, that the inventor can await, without the pang—at least of impatience—if not of anxiety, the moment of the realization, by actual trial, of his hopes and his calculations. We can all readily imagine the throb of anxiety with which Galileo pointed his glasses for the first time to the moon—with which Watt saw the cylinder of his model exhausted, and the piston descend under the action of his separate condenser—and Stephenson, the stupendous iron tube at Conway resting for the first time straight as a ramrod on its two piers—these are moments of anxiety and of triumph, which place the inventor of a machine and the architect of a structure on a par with the discoverer of a planet, or with the author of a theory. "Whenever an original mind produces new combinations of thought and feeling," says Sir James Mackintosh, with equal impartiality and truth, "whether its means be words or colours, or marble or sound, or command over the mighty agents of nature; whether the result be an epic poem, or a statue, or a steam-engine, we must equally reverence those transcendent faculties to which we give the name of genius."[2] It is almost needless to add the caution, that such praise is only applicable when the invention is such as to call forth the qualities which distinguish the Philosopher. It is not the mere command over the agents of nature which challenges our admiration, it is the foresight, the patience, the conceptive faculty, the clear-sighted and confident anticipations of what will be the results of natural laws acting in given circumstances, these circumstances being in some essential particulars *new*. Merely to adopt known contrivances, where experience has already anticipated the result, may exercise judgment, but hardly genius; and to make contrivances in which the result depends rather upon laws of geometry than of physics, hardly come within the scope of these remarks.

As in Watt's steam-engine.

(36.) Watt's Parallel Motion, perhaps the most *ingenious* of his inventions, would not have made a great reputation; nor does the endless variety of machines used in the arts, as in spinning, printing, and paper-making, stand higher. It is when the inventor places Matter in new relations to Force, or derives power from new sources, or teaches Light or Electricity to act under new conditions, that he becomes really a Mechanical Philosopher.

(37.) The limits of art.

It is not given to man to endue matter with new properties, or to prescribe the laws under which his inventions are to take effect. A new motive power, a new form of construction, are experiments on the resources of nature under new conditions.

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[1] See Carnot, *Puissance Motrice du Feu*, and the writings of M. Clapeyron, Professor W. Thomson, &c.

[2] Speech at a meeting for erecting a monument to Watt, in Arago's Eloge of Watt.

(38.) Solutions of mechanical as of mathematical problems sometimes manifold.

In fact, even in comparatively simple cases, we cannot set forces to act on matter, or dispose matter so as to resist force, without doing not only what we intend to do, but also a great deal more. Man may put powers in motion which he is unable to control; and whilst he calculates confidently upon the effects of such and such dispositions of force or resistance, he may overlook consequences equally necessary, because resulting from laws of nature which are either unknown to him, or the magnitude of which he had overlooked, in considering those only which he required. A complicated mechanical contrivance may be compared to the mathematical solution of a problem. It represents commonly a great deal more than is meant to be derived from it. It may represent several distinct results, some possible, some impossible, and of the former only one, it may be, congruous to the real conditions of the problem proposed. In mechanics, the laws of nature are as impatient of control as the laws of quantity in geometry, and the engineer may find, too late, that nature has solved his problem differently from what he expected. But even when successful, it is to be presumed that his own contrivance contains within it results unforeseen by himself. If he is wise he will become a student in his own workshop. The material contrivances are indeed his own, but the powers which they awaken or distribute are beyond his control. Even if his reading of the equation be strictly correct, there may remain in the background others no less important.

(39.) The considerations here imperfectly laid before the reader are intended to justify the introduction of certain practical topics into the present Dissertation, which, though many readers will see their insertion without surprise, or would have been sorry to find them omitted, others possibly may think more or less independent of, and separable from a scheme already sufficiently extensive and intricate, if confined to mere subjects of scientific doctrine, to the exclusion of its applications. My chief reason for including such subjects as the steam-engine, the strength of materials and some great examples of construction, and the electric telegraph, is that these important practical improvements are both historically and logically interwoven with the progress of pure or abstract physics. They have besides impressed upon the character of scientific discovery of the last hundred years a peculiar stamp which it would have been absurd to ignore while endeavouring, within a moderate compass, and in the plainest language, to convey a vivid though comprehensive sketch of the advancement of Natural Philosophy during this and the preceding, or rather two preceding generations.

(40.) Lessons of ordinary experience.

It is not to be imagined that the difficulty of the problems which occupy the speculative philosopher, or the comprehensiveness of mind required for their solution, diminishes in any degree as we descend from the regions of pure science to the walks of every-day life—from the vast periods and majestic motions which astronomy enables us to explain and predict, to the common details of the workshop and the railway. In fact, the former are to be regarded as the *simpler* investigations, whilst our terrestrial agents have their effects modified by the diversified states of aggregation and various mechanical properties of matter, and by the numerous modifications of force arising from heat, electricity, or magnetism, to which it may be exposed. We have as yet made but an insignificant advance towards that completer system of Natural Philosophy of which Newton's will form but one section, in which all the properties of matter and their consequences shall be as well understood as the particular property of gravity is at present. Many of these are to be learned by daily observation of the effects which occur in the ordinary progress of civilization amongst us. We are continually performing experiments on a great scale and on purely commercial principles, which no individual philosopher or merely scientific society could have ventured to attempt. And in the midst of these appeals to experience, unexpected results are frequently occurring which send us back once more to the study of first principles, which, indeed, while they confound the empiric, do but establish the reputation of the philosophic engineer, who seldom fails to turn them to good account, both in his theory and practice.

CHAPTER II.

PHYSICAL ASTRONOMY AND ANALYTICAL MECHANICS.

§ 1. LAGRANGE.—*Variation of Parameters—Application to Physical Astronomy. The Stability of the Planetary System;* Laplace; Poisson. *Moon's Libration.*

(41.) Lagrange.

The period of Lagrange's most celebrated labours extends so far back into the preceding century, that having been already mentioned in Sir John Leslie's Dissertation, it might have been excusable, with so great a mass of matter before us, to have passed them over without farther notice. But they are so intimately connected with the most salient points of the history of physical astronomy, down even to the present time, and are so interwoven with the discoveries of Laplace, and represent altogether so much of the substantive character of the progress of the age, that I have thought it necessary to devote a small space to the recital of a few of the most prominent of them, having regard to the intellectual portraiture of the man as one of the most pre-eminent and successful reasoners of his class who have ever done honour to their race. I shall repeat as little as possible what has been said elsewhere, and confine myself to only two or three topics.

(42.) His birth and education; his contemporaries.

Joseph Louis Lagrange was born at Turin in 1736; he died at Paris 10th April 1813. His first paper was written at the age of 17 or 18, and his end was accelerated by the unremitting ardour of his labours at the age of 77. He was consequently an original author during *sixty years;* and for the greater part of this period he, together with Laplace, monopolized the greatest discoveries connected with analysis and physical astronomy, and exercised an almost undisputed authority in the more recondite sciences. Euler, Lagrange, and Laplace, by a singular coincidence, lived to the respective ages of 90, 77, and 79, and all retained their activity nearly to the last. They produced, by the continuity and friendly rivalry of their labours, carried to an extent in each case which only astonishing physical vigour united to astonishing mental aptitude could have produced, during almost a century, an impression on the progress of science altogether remarkable. This coincidence was the more happy, because physical astronomy was exactly in that predicament when nothing less than such a combination of intelligence and intensity of application systematically urged, could have carried Newton's theory through the difficulties which at that time beset it—difficulties which left the *Principia* for so many years alone, and far in advance of the general intelligence of the age.

(43.) Euler and Laplace.

The pregnant suggestions of Euler were developed and applied by Lagrange, and the triumphs of Lagrange—nay, even his occasional failures—were the immediate precursors of some of Laplace's happiest efforts.

(44.) Variation of parameters;

Amongst the former we reckon the *method of the variation of parameters*, expounded to a certain point by Euler, though, as in many other cases, his results were vitiated by the haste and inaccuracy of his calculations. That Lagrange borrowed the idea from Euler cannot admit of a doubt, any more than that he was indebted to him for the principles of the Calculus of Variations. Lagrange, with customary truthfulness, even to his latest days, always spoke of Euler as his best instructor and model, and as the chief of modern mathematicians, Newton only excepted. We know that he so regarded him in the case of the calculus of variations which he studied in Euler's "Methodus inveniendi lineas curvas, &c.," during the first two years of his application to the higher mathematics;[1] whilst Euler, with equal candour, acknowledged the transcendent genius of the rising geometer, forcing its way where he himself had failed.

(45.) its signification.

The method of the Variation of the arbitrary constants or Parameters, though it may be regarded in one point of view as a merely analytical artifice for effecting integrations, is in reality a conception purely geometrical, first introduced by Newton[2] under the name of "revolving orbits," and applied by him to the explication of the conception (to use a recently introduced phrase) of the lunar inequalities. Neither the moon nor any planet really describes a mathematical ellipse (in consequence of the mutual perturbations of the heavenly bodies). They describe curves of double curvature in space, of which we could form no intelligible idea, except by referring them to the very approximate type of the ellipse, of which the eccentricity, line of apsides, inclination, &c., are continually varying, not only from one revolution to another, but throughout every part of a revolution. This representation is not only convenient, but strictly accurate. At *each instant* the moon or planet is describing a portion of an ellipse, which may be called the *instantaneous ellipse*, and which may be defined as the particular ellipse which the body would go on to describe if it were at that instant freed from all perturbation, and allowed to complete a revolution under the single influence of its acquired motion and the central force. To take

Instantaneous ellipse.

Lagrange's early studies.

[1] The following is a list of the books he then read, taken from a paper probably little known, which appeared soon after the death of Lagrange in the *Moniteur* newspaper, and which was translated in Thomson's *Annals of Philosophy*, vol. iv. He first read Euclid's *Elements*, Clairaut's *Algebra;* then, in less than two years, and in the following order, Agnesi's *Analytical Institutions*, Euler's *Analysis of Infinites*, John Bernouilli's *Lectures*, Euler's *Mechanics*, the two first books of Newton's *Principia*, D'Alembert's *Dynamics*, and Bougainville's *Integral Calculus*, Euler's *Differential Calculus* and *Methodus Inveniendi* —a pretty course of mathematical reading for a youth between 17 and 19.

From the same paper we abridge a few practical directions given by Lagrange for the study of mathematics, which, if tolerably obvious, are interesting from the extraordinary genius of the man, and from his singular reticence on subjects of a personal nature. "I never," he said, "studied more than one book at a time; if good, I read it to the end." "I did not perplex myself with difficulties, but returned to them twenty times if necessary. This failing ,I examined another author." "*I considered reading large treatises of pure analysis quite useless.* We ought to devote our time and labour chiefly to the applications." Thus he read Euler's *Mechanics* when he had acquired a very slight knowledge of the differential and integral calculus. "I always read with my pen in my hand, developing the calculations, and exercising myself on the questions."

"From the very beginning of my career, I endeavoured to make myself master of certain subjects, that I might have an opportunity of inventing improvements; and *I always, as far as possible, made theories to myself of the essential points*, in order to fix them more completely in my mind, to render them my own, and to accustom myself to composition." "Finally, I every day assigned myself a task for the next. I learned this custom from the King of Prussia."

[2] This Lagrange himself points out in his *Mécanique Analytique*.

a single example; the planet Uranus has not yet completed one revolution since the time of its discovery in 1781, yet its observed path differed so much from a true elliptic arc (even when we allow for the perturbation of Jupiter and Saturn), that the orbit which satisfied the observations from 1781 to 1800 would not satisfy those from 1800 to 1820; and since 1820 a new orbit had to be computed for every few years, so great were the variations of the instantaneous from any permanent ellipse. These variations led to the discovery of the planet Neptune.

(46.) Planetary theory. To adapt the notion of the perpetual variation of the elliptic elements to analytical calculation, and to ascribe to each planet its influence in perturbing the elliptic motion of the others, was the great problem mainly solved by Lagrange. In the planetary theory, where the perturbations are all very small, on account of the excessive preponderance of the mass of the sun, the motion of each planet may be considered as under the *separate* disturbing influence of every other, and the whole perturbation is the sum of the separate perturbations.

(47.) Periodic and secular inequalities. Now, these perturbations of elliptic motion may be divided into two great classes, which Lagrange first, in 1782, included in a common analysis, which expressed the disturbed elements of planetary motion by two sets of terms: those which include the relative positions (or configuration) of the disturbing and disturbed planets being the one set, and those which included *only* the masses and elements being the other. The former are called *periodic*, the latter *secular* inequalities. The distinction is important, since, after a sufficiently long time, two planets (suppose the Earth and Mars) will have been presented to one another in space in every conceivable position of which, by the form and position of their orbits, they are susceptible, a like recurrence of configurations will recommence, and like perturbations will result. Such influences, though running through long periods, will be evidently *recurring.* But there is another class of disturbances, which may in thought be entirely separated from the former, being the ultimate or *average* effect of the influence of one planet on another, arising, not from the position of the planets in their orbits at any one time, but from the position of the orbits themselves. Thus in a single revolution (and on account of the independent excentricities of the orbits during many successive revolutions) of Mars and the Earth, the attraction of the former on the latter sometimes conspires with the sun's attraction, sometimes opposes it, sometimes urges the Earth forward in its path, and sometimes pulls it back, producing numerous *periodic* inequalities; but it is quite evident that, in the *long run*, the attraction of Mars on the Earth tends to pull it away from the sun, and to diminish the effect of the solar attraction—in fact, to increase the length of our year; and that this influence will be precisely the same if we take the average of a great many revolutions now, and compare them with a similar average hereafter, provided that the orbits undergo no permanent change. This, therefore, though not strictly an *inequality*, because the length of the year is *permanently* changed by it, shows an average effect independent of the configuration of the planets. An example of a true secular inequality is the revolution of the line of apsides or major axis of any orbit, by the influence of the disturbing forces of the planets, whether interior or exterior to the one considered.

(48.) Change of apsides and excentricities. Few of the secular inequalities have been detected by observation throughout the entire records of Astronomy. It is known, however, that the apsides of the planetary orbits (at least in the case of the old planets) all *progress*, with the exception of those of Venus, which retrograde, and that the inclination of all is at present diminishing. The excentricity of the Earth's orbit is decreasing at the rate of 40 miles per annum. The exclusive dependence of the secular inequalities on the *orbits*, not on the *places* of the planets, may be well illustrated by a method actually employed by Gauss for computing them (though it does not appear to be attended by any special advantage). He conceives the orbit of the disturbing planet to be strewed with attractive matter, whose thickness at any point is inversely as the planet's velocity there, or directly as the time of its sojourn in any small length of the orbit.

(49.) The method of variations of the elements is evidently most applicable to the determination of Secular Perturbations; for to compute by means of it the ordinary inequalities involves an apparently unnecessary labour. The place of a planet is completely determined by three co-ordinates—its longitude, latitude, and radius vector; whilst the elements of the orbit are six in number, and when found, a further calculation must be made to find the co-ordinates of position. The more direct method of deducing the co-ordinates at once from the conditions of perturbation, was generally followed until 1808, when Lagrange and Laplace almost simultaneously devised methods of using the variation of the elements with directness and despatch in the calculation of Planetary Perturbations. In the estimation of the second and higher orders of disturbance, it has even the advantage in these respects over the other method.

(50.) Stability of the solar system. *Stability and Permanence of the Solar System.*—After it had been clearly recognised, principally by the labours of Lagrange, that the elements of the planetary orbits are in a condition of perpetual change, it came to be a most interesting question how far such variations were likely to be continuous, and ultimately so great as to modify altogether the forms of the orbits, and even endanger the separate existence of the planets. This is a question which has excited a very general, as well as scientific interest. It is evident that the variations of the different elements are not all equally important in affecting the permanence of an orbit. The five properly orbital elements (the sixth being the longitude of the planet on its orbit at a given time) may conveniently be considered thus: 1st, the major axis, which, for one and the same system, involves the periodic time or mean motion; 2d, the excentricity and position of the line of apsides; 3d, the inclination and position of the line of nodes. Of these, the stability primarily depends upon the first. If the major axis and mean period increase or diminish without limit, the planets will diverge into infinite space, or rush after myriads of ages to utter annihilation in the burning embrace of the sun. The latter alternative was the popular belief about the middle of last century, and was maintained by the grave authority of Euler; whilst Darwin, in his florid but picturesque language, described the order and beauty of the planetary system as but a little more permanent than the glowing ornaments of the gay parterre.[1] The principal reason for this conclusion, and its refutation, will be mentioned in the next section.

(51.)
Laplace's share in the discovery.

The first person who perceived the probable stability of the major axes and mean motions was not Lagrange but Laplace, who, in a paper published in 1773, gave a demonstration, the sufficiency of which has not been doubted, that the major axes are invariable, so far as the influence of the principal terms of the disturbances are concerned, that is as far as terms containing the cubes of the excentricities inclusive, and the first powers of the perturbing masses. Nor does Laplace appear to have doubted that the mutual distinction of the terms, including secular changes, was not accidental, but would extend also to the farther approximations. Lagrange, however, in a celebrated though short memoir of 1776, demonstrated the truth of the conclusion for the higher powers of quantities contained in the perturbations of the first order, and that by methods peculiarly comprehensive and elegant, which he farther extended in 1781 to the other five orbital elements, showing the periodicity within certain narrow limits of the excentricity and inclination, the only elements, except the major axis, whose variations menace the stability of the system. Yet it is quite impossible to separate completely the names of Lagrange and Laplace in the effectual demonstration of this important truth, the former as frequently indicating the means of overcoming the more purely mathematical difficulties, as the latter was suggestive and far-sighted in anticipating their application to the peculiarities of our system.

(52.)
Limits of excentricities and inclinations of planetary orbits.

Laplace discovered (1784) two remarkable theorems which limit the *whole* amount of the excentricities and inclinations of the orbits of the planetary system, showing that if once small, they must ever remain so; and, in particular, that the most massive planets of the system (Jupiter and Saturn) must also undergo the most trifling variation in these respects. In the case of the small planets between Mars and Jupiter, a wider range may occur (as indeed we practically find to be the case), without endangering the permanency of the whole. It also follows that these variations, though "secular," are practically "periodic;" that is, that the excentricities and inclinations oscillate about certain mean values and within extremely narrow limits, the periods of these oscillations being also of vast duration. Concerning such changes, theory is our only guide. The whole duration of astronomical records can barely reveal the existence of two or three of them, and tells us absolutely nothing of their remoter consequences. Lagrange calculated the superior limits of the excentricities of the larger planets, and M. Leverrier has recently, by more accurate methods, obtained results nearly coincident. According to him, the maximum excentricity of the Earth's orbit is 0·07775, the minimum 0·003314, so that it can never be quite a circle. It is now diminishing, and will continue (according to the same geometer) to do so for 24,000 years, when it will begin to increase. The inclinations of the Earth's orbit to its equator, and also to a fixed plane, are confined within definite limits which are not perhaps very perfectly known.

(53.)
Motions of apsides and nodes.

The motions of the apsides and nodes of the orbits which gradually complete the entire circumference have manifestly no tendency to affect the stability of the system. The grand cycle of the Earth's perihelion will only be completed in 110,000 years. It coincided with the vernal equinox 4089 years before Christ, a period (as Laplace remarks) nearly coincident with that assigned by chronologers to the creation.

(54.)

These results may be considered as among the most astonishing with which science brings us acquainted. The range of insight which man has acquired into the past and future history of the universe throughout periods, compared to which, the whole existence of his species is but a span, enhances our admiration of the reasoning power which can attain to knowledge so high and excellent. And the sublimity of the contemplation is increased when we recollect that these recondite truths are all consequences of a law so simple as that of gravity. Observation will reveal only to a late posterity the secular modifications of the planetary orbits which geometry now predicts to us. Some of the ellipses will elongate, whilst others tend to become circles; their planes will vary in inclination, but ultimately be stayed within the limit which human sagacity had predicted myriads of years before. "These," says a French analyst, "are the pendulums of eternity, which beat ages whilst ours beat seconds." And amidst all these variations, subject to law and to impassable limits, the Major Axes of the orbits preserve a stedfast uniformity, or are subject only to transient fluctuations; and thus permanence arises in the midst of change, and the perfection of the system is demonstrated by the very nature of the disturbances which seemed at one time inevitably to limit its duration.

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[1] "Roll on ye stars! exult in youthful prime,
Mark with bright curves the printless steps of Time,
Near and more near your beamy cars approach,
And lessening orbs on lessening orbs encroach;
Flowers of the sky! ye too to age must yield,
Frail as your silken sisters of the field!
Star after star from heaven's high arch shall rush,
Suns sink on suns, and systems systems crush,
Headlong, extinct, to one dark centre fall,
And Death and Night and Chaos mingle all!
'Till o'er the wreck, emerging from the storm,
Immortal Nature lifts her changeful form,
Mounts from her funeral pyre on wings of flame,
And soars and shines, another and the same."

Darwin's Botanic Garden, Canto iv., line 367.

(55.) Poisson's addition to the theory.

It remains to add, in closing this interesting discussion, that Lagrange himself had not quitted the field before his able disciple and follower, Poisson, pursued the inquiry of the stability of the system, and the permanency of the major axes particularly, to a degree of approximation not before attempted. He included the perturbations of the second order, or those which arise by correcting the elements for the disturbances first found, and including the effects of the correction in the modification of the perturbations themselves. These also are subject to the same laws as found by Laplace and Lagrange for lower degrees of approximation; and as MM. de Pontecoulant and Leverrier have confirmed the result (at least for all the larger planets of the system), we may conclude it to be a truth as firmly established as any negative fact can be, that our system is arranged for a duration apparently indefinite; that if the planets cease to roll, and the sun and moon to do their office in enlightening the world, it must be in all probability by an interposition of Almighty power, as direct and immediate as the creative energy by which they were launched into space, and (our earth at least) peopled with successive races of animated beings.[1]

(56.) Lagrange's other writings.

We have, in the commencement of this section, disclaimed the intention of entering at large upon the history of Lagrange's discoveries. They fell more properly under the scope of the preceding Dissertation, and an able summary and enumeration of his writings by no less competent a person than Dr Thomas Young will be found in the alphabetical part of this Encyclopædia. I will only add, that while scarcely a topic in physical astronomy, or in pure mathematics, failed to receive important additions from his pen, his memoirs on the Libration of the Moon, his solution of several problems of Sound and vibrating strings, and his methods of computing the perturbations of Comets, are amongst his contributions to science, most vividly remembered and most justly admired as models of analytical ability. He himself is stated to have preferred, amongst all his papers, one in the Turin Memoirs of 1784, on the Integral Calculus.[2]

(57.) Libration of the Moon.

With reference to the Lunar Libration, Lagrange confirmed the singular conclusion of Newton, that the moon is a spheroid, having three unequal axes, the longest of which is always approximately directed to the earth, and the shortest is her axis of rotation. In consequence of this, the moon, of *necessity*, revolves on her axis in the exact time that she circulates round the earth (supposing that at any time these periods were nearly, though not absolutely, coincident), and is subject (as Newton had divined) to a species of oscillation upon her axis, owing to the line of the earth's attraction not always coinciding (in consequence of the moon's irregular motion in longitude) with the moon's greatest diameter. This constitutes a *physical* libration, as inequalities in longitude, by enabling us to see more or less of the lunar hemisphere diametrically opposed to us, constitute an *optical* libration, or apparent to-and-fro motion on her axis. In this investigation Lagrange first used the combination of D'Alembert's Principle with that of Virtual Velocities, afterwards fully expanded in the *Mécanique Analytique*.[3]

(58.) Lagrange was happy in passing his days with

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[1] No reasonable doubt exists as to the stability of the planetary system to which our earth belongs, as it is at present constituted. To what extent the laws of order which we observe in it might be transgressed with impunity, it is more difficult to say. The investigations of Laplace and Lagrange assume the motion of the planets in one direction, and their moderate excentricities and inclinations, as *conditions* of the guarantee of stability. But it does not appear by any means certain that all these conditions are essential, and consequently the argument which has been sometimes employed, that the concurrence of many independent circumstances were requisite to the stability of the system, is at least incomplete. Compare Laplace, *Système du Monde*, edit. 1824, vol. ii., p. 29, and Herschel's *Outlines of Astronomy*, art. (669).

[2] It is No. 17 in the enumeration of his papers in the article LAGRANGE in the Encyclopædia.

M. Hansen on the moon's figure.

[3] Very recently (1854), M. Hansen of Gotha, a most eminent living authority, has somewhat modified the received opinion respecting the moon's figure. He finds that the presumed ellipticity of the moon in the direction of the radius of her orbit is not justified by observations, which ought to show a slight variation in her horizontal diameter when the *libration* presents to us our satellite in a slightly varied aspect. And he infers from an elaborate investigation of the lunar observations, that her centre of figure does not coincide with her centre of gravity, but lies about 31 English miles nearer to us than the latter. M. Hansen adds that the existence of such a protuberance of the moon's body relatively to the centre of gravity on the side which we can alone view, would account for the apparent absence of water and air, which may abound upon the opposite side.—*Astronomical Society's Notices*, vol. xv., p. 13.

Private character of Lagrange.

the tranquillity of a philosopher. He was respected and rewarded alike by kings and democrats—he was honoured and promoted in three great states, Sardinia, France, and Prussia. Though patronized by the despotic Frederick, and lodged in her palace by the gentle queen of Louis XVI., he escaped the misfortunes of almost every one of his contemporaries, including Laplace, Lavoisier, and Delambre; he retained his scientific appointments throughout all the frenzy of the French Revolution. His mildness of disposition and disinterested devotion to science, more than the European celebrity of his name, contributed to this result. He was equally fortunate in his scientific relations. Euler, D'Alembert, and Laplace, whilst they were emphatically his rivals, were also his sincere friends. If he ever felt jealousy, it was perhaps towards those who, he thought, attained too easily by circumstances to a high reputation: Monge seems to have been of this number. It is remarkable that for a series of years Lagrange diverted his mind altogether from mathematics, and studied chemistry, natural history, and even metaphysics. His reply is well known, when asked how he liked the first of these sciences; "Oh," said he, "I find it on trial as easy as algebra." It may be doubted whether in our own day he would have given as favourable an opinion!

(59.) He was unassuming in conversation, and disliked speaking of himself. His commonest answer was "I don't know." He was happy in his domestic relations, and died universally honoured and regretted, 10th April 1813.

§ 2. Laplace.—*Lunar Theory Improved.—Great Inequality of Jupiter and Saturn.—Theory of the Tides.*—Young; Dr Whewell; Mr Airy.—*Theory of Probabilities.—Character of Laplace as a Physicist and Author.*

(60.) Laplace.

Pierre Simon Laplace has generally, and not without reason, been considered as a sort of exemplar or type of the highest class of mathematical natural philosophers of this, or rather the immediately preceding age. The causes of this, and the degree in which it is warranted, we shall endeavour to state towards the close of this section. In the meantime, finding it quite impossible within our prescribed limits to notice, ever so briefly, all his more material investigations, we shall select three or four marked by their originality and general interest. Such are, 1. His improvements of the lunar theory. 2. His discovery of the cause of the great inequality of Jupiter and Saturn's motions. 3. His theory of the tides. 4. His work on probabilities. 5. We shall consider his character as a general physicist, and as a writer.

(61.) Improvements in the Lunar Theory.

I. First, then, we are to speak of the improvements of the lunar theory effected by him. The application of Newton's own principles to the perfecting of the theory of the moon's motion has been related in Sir John Leslie's Dissertation, and so far as the labours of Clairaut, D'Alembert, Euler, and Mayer, are concerned, belongs distinctly to the middle portion of the last century. The errors of Mayer's tables little exceeded *one minute* of space, which was twice more accurate than in Halley's time. With one important exception, the main outstanding differences between theory and observation had disappeared. The eclipses recorded in the Arabic and Chaldean annals could not (as Halley first observed) be correctly explained by the motion of the moon as given by recent tables. At length it became admitted that the *mean motion* of the moon has been accelerated from century to century by a minute quantity, which, in the lapse of thousands of years, has become recognisable. It amounts to this, that the moon comes to the meridian two hours sooner than she would have done had her *present* period remained invariable from the earliest astronomical records of eclipses. It is at once evident how delicate a test this must be of changes otherwise imperceptible. The effect on the dimension of the moon's orbit may be thus expressed, that at each lunation she approaches nearer to the earth than during the last by *one-fourteenth* of an inch! thus describing a spiral of almost infinitely slow convergence. The minuteness of the effect may be illustrated by the shortening of the pendulum of a clock by an amount absolutely insensible, which yet, after days and weeks, will alter by many seconds the time shown by the hands.

(62.) Secular acceleration of the Moon.

After several unsuccessful speculations as to the *cause* of this anomaly, Laplace, in 1787, thus satisfactorily accounts for it:—It is well known that the sun's attraction on the earth and moon lessens, on the whole, the tendency of the latter to the former, and lengthens permanently the lunar period. But, so far as this effect is *uniform*, it does not directly appear. The effect is greater, however, when the earth is near the sun than when it is farther off. The lunations are therefore longer in winter (when the earth is in perihelion) than in summer. This is called the annual equation, and the amount is very sensible for this reason, that (as may be easily seen) the perturbing force varies inversely as the cube of the sun's distance. Now, though the earth's *mean* distance from the sun has not varied in the lapse of ages, the excentricity of the earth's orbit has been diminishing from the earliest historic times, and the average inverse cube of the distance has been also slowly increasing. The result is that the moon's motion has been continually accelerated. Now, we have in the last section referred by anticipation to this acceleration as having led to the belief that the moon must at last fall to the earth. Laplace's discovery, however, shows that the acceleration has a limit, depending on that of the excentricity of the earth's orbit, which having reached its minimum, the lunar mean motion will begin to be retarded, and will continue so through a vast cycle of ages, and so on alternately. Theory enables us to assign, with considerable accuracy, the amount of the acceleration, which is now about 10″ of longitude in a century.[1]

(63.) Earth's ellipticity and solar parallax deduced from the moon's motion.

Besides this very satisfactory discovery, Laplace investigated three of the lunar inequalities in a manner leading to curious and unexpected results. Two of these depend on the spheroidal figure of the earth. The nutation of the earth's axis, which is due to the attraction of the moon on the protuberant equatoreal parts of the earth, is exactly reproduced by the equivalence of action and reaction in the movements of the lunar orbit, only less perceptible in degree on account of the length of the leverage at which they are effected. The inequality of the moon's motion in latitude may be used to determine the degree of compression of our globe at the poles. Laplace deduced from the Greenwich observations of the moon the fraction $\frac{1}{304{\cdot}6}$, and, from a relative inequality in longitude, $\frac{1}{305{\cdot}05}$; a coincidence really astonishing, not only as between themselves, but also when compared with the mean result of laborious investigations by actual measurement of the earth's surface. The other result we referred to was the determination from the lunar theory of the solar parallax,—in other words, the distance of the earth from the sun, which enters into the expression of a certain inequality of the moon's motion in longitude. From the observed amount of this inequality, Laplace obtained a value of the solar parallax exactly coincident with that obtained with so much labour on occasion of the transit of Venus in 1769. Strange and admirable result (as Laplace himself remarks), that the astronomer, immured in his observatory, and watching our satellite through his telescopes, and reading the result by the aid of mathematical analysis and the theory of gravitation, should be able to determine the figure of our earth, and its distance from the sun, with perhaps quite as great accuracy as by any direct measurements. Truly the wonders of fact exceed those of fiction, and the divinations of true science may match the pretensions of her counterfeit, astrology.

(64.) Theory of Jupiter's satellites.

In conclusion of this subject, I regret that space does not allow me to advert particularly to Laplace's remarkable success in accounting for some singular peculiarities in the system of Jupiter's satellites, arising from, and partly occasioning, an exact commensurability in the periods of some of them (which Sir John Herschel has lately observed to hold also in the Saturnian system in a somewhat different manner), a case which we have seen to be especially excluded in the instance of the planets, and which has been pronounced by a very competent judge (Mr Airy) to be "the most curious and complicated system that has ever been reduced to calculation." It ought to be stated, however, that Laplace's discoveries were based upon a previous and highly original investigation of Lagrange.

(65.) Long inequalities of Jupiter and Saturn.

II. In the second place, we shall briefly state the nature of Laplace's happy explanation of a great inequality of the solar system, to which, like the fact of the lunar acceleration, especial attention had been called by the sagacity of Halley, and which, like it, resisting all the efforts of geometers to interpret, threatened the credibility of the Newtonian theory of gravity. We are therefore to look upon this step as something more than a solution of a difficult problem; it was a new, peculiar, and unsuspected combination of circumstances on which it depended, and the solution afforded a key in all time coming to difficulties depending upon a like cause.

(66.) History of these inequalities;

Halley had ascertained, that by comparing modern with the most ancient observations of Jupiter and Saturn, the mean motion of the former planet had been accelerated, and that of the latter retarded. Lambert remarked subsequently that, if we confine ourselves to modern observations alone, an opposite change would appear to be in progress. The amount of the error of the tables was so considerable (amounting to 20′ or more in the middle of the eighteenth century, and capable, in fact, of becoming much larger), as to have been (along with the apsidal motion of the lunar orbit) one of the first subjects of anxiety and speculation to geometers, when the Newtonian theory came fairly into discussion. For nearly *forty years* this stubborn inequality was vainly attempted to be accounted for by Euler, Clairaut, D'Alembert, Lagrange, and by Laplace himself, before the latter hit upon the true cause of the anomaly. It was long, and naturally, believed to be a properly *secular* inequality, arising from the average mutual effects of the planets Jupiter and Saturn, though Lambert's remark rendered this less probable. It was in the course of the consequent research that Laplace proved that the mutual action of the two planets could produce their origin; their amount.

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[1] We here add that very recently Mr Adams has discovered that Laplace, and also his followers, in confining their attention to the *radial* effect of the sun's interference with the lunar motions, as affected by the excentricity of the earth's orbit, have unwarrantably assumed that the area described by the moon a unit of time is invariable. He finds, on the contrary, tangential perturbations depending on the same cause, and sensibly modifying the amount of secular mean motion deduced from theory.—(*Philosophical Transactions*, 1853.)

no *permanent* alteration of the mean motion of either; a conclusion which, as we have seen in the last section, he afterwards generalized for the planetary system. Several other memoirs by Lagrange and himself followed; and when the question became thus narrowed to *periodic* perturbations only, Laplace, with characteristic ardour and resolution, determined to search out every term which could affect the result; an irksome task, less congenial to the generalizing spirit of Lagrange. He had already noticed, in his memoir of 1773, that Euler and Lagrange had, in their researches on this very subject, omitted terms, multiplied by sines and cosines of very small angles, which yet might, in the process of integration, become considerable by the largeness of the coefficients. Eleven years later he detected, in the expansion of the mutual perturbation of Jupiter and Saturn, terms of this kind. The coefficient (or maximum value of the term) is in this case divided by the *square*[1] of the same quantity which renders the angle under the sine or cosine small. These terms were indeed likewise multiplied by the *cubes* of the excentricity, or like small quantities; but notwithstanding this, by reason of the small divisor just mentioned, they were capable of attaining a formidable magnitude; in the case of Jupiter, to 21′, and of Saturn, to 48′ or 49′. That so small a force should produce so large an effect is due to the *very long period* of the most considerable portion of this inequality, which, in fact, led to its being confounded with perturbations properly secular. The period of complete recurrence of the effects is about 920 years; and during half this time the motion of one planet is being constantly accelerated, and that of the other retarded; during the other half the action is reversed. An effect continually increasing or diminishing for so long a time, and between the two most massive of the planetary bodies, is evidently liable to become considerable. The maximum displacement of Jupiter and Saturn Laplace found by calculation to have occurred in 1560, explaining the peculiarity above mentioned in the comparison of ancient with modern observations.

(67.) Their periods.

When we look to the physical cause of the largeness of these particular perturbative terms, it is found to be this;—that the period of revolution of Jupiter compared to that of Saturn, is almost as the numbers 2 and 5:—in other words to the near commensurability of the mean motions. Were they *exactly* in proportion to these numbers, formidable and permanent changes would possibly result in the orbits. As it is, the planets come into conjunction when Jupiter has completed 5 revolutions, and about $\frac{1}{14}$th more; Saturn 2 revolutions, and $\frac{1}{14}$th more. Consequently the point of conjunction travels round the circumference after about 44 conjunctions have occurred, which requires nearly 2700 years. But a little consideration will show that conjunctions occur successively at three nearly equidistant points of the circumference; consequently the two planets will have been presented to one another in every possible variety of configuration, when the point of conjunction has travelled one-third round the circumference, that is in about 900 years.

(68.) The effect of this great improvement in the Theory of Jupiter and Saturn was, that the most ancient observations were completely reconciled with the modern, and the modern with one another; the errors of the tables were immediately reduced to *one-tenth* of their former amount, and soon after to much less.

(69.) Theory of the Tides.

III. The third topic which I must shortly discuss in connection with the career of Laplace, is the Theory of the Tides.

(70.) Newton's. D. Bernouilli's, or the Equilibrium Theory.

The Newtonian Theory of the Tides has been explained in Mr Playfair's Dissertation, but its progress during the 18th century has not been adverted to in the continuation by Sir John Leslie. It will be sufficient to state here, that it was pursued into its consequences with ability and success by Daniel Bernouilli, who in 1740 shared a prize of the French Academy of Sciences on this subject, along with Euler, Maclaurin, and Cavalleri, a Jesuit, the last a supporter of the Cartesian vortices. It was, perhaps, the concluding honour paid to that once popular theory.

(71.) Its results.

The Tidal Theory of Newton and Bernouilli presumes the earth to be at rest; and also the waters of the ocean to be at rest, and at every moment in a state of equilibrium between the force of gravity, tending to the earth's centre, and the lesser forces tending towards the sun and moon. That a theory, founded on suppositions so far from the truth (not to mention the irregular distribution of sea and land on the earth's surface), should in any manner or degree represent correctly what happens, may be matter of just surprise. The leading phenomena are however tolerably consistent with it; the dependence of the great tides on the moon's position with respect to the meridian of the port; the spring and neap tides when the sun's action and that of the moon conspire with or oppose one another; the *priming* and *lagging* of the tides depending on the displacement of the vertex of the compound ellipsoid due to the combined effect of the sun's and moon's attraction, depending therefore on the moon's elongation from the sun; the effects of the moon being in the nearer or remoter part of her orbit; all these facts are indicated by the Equilibrium Theory (as it has been termed), and are also results of observation. The theory, however, does not give the true depth of tide, nor (except in casual instances) does the time of high and low water coincide with theory; besides many minor imperfections.

(72.) Laplace had the singular boldness to attempt the solution of a problem, which is more one of hydro-

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[1] In consequence of a *double* integration in respect of the time.

Laplace's Dynamical Theory.

dynamics than of astronomy, and to estimate all the causes of movement of the particles of a heavy fluid, surrounding a spheroidal rotating nucleus exposed to the attractions of the sun and moon. This he did in a series of memoirs, more systematically condensed in the *Traité de Mécanique Céleste*, and it may safely be affirmed that no other mathematician of his day was equal to the labours and disappointments of an investigation attended with every species of difficulty, in which each result must be attained by a combination of general sagacity with mathematical rigour, and for the verification of which observations were yet in a great measure wanting. The Theory of the Tides was, upon the whole, the most arduous and complicated problem which could well be conceived, in a branch of science (hydrodynamics) hitherto remarkably little successful in predicting the results of the most simple and arbitrarily selected experiments.

(73.) Its difficulty.

That Laplace has been in a measure successful in such an undertaking must be considered the highest test of his genius, especially in reducing his mathematics to practical application; but the result has been a treatise so profound and obscure (I mean as regards the tide theory), that very few persons have attempted to master its difficulties. Mr Airy, the present astronomer royal, has done a great service to men of science, and to that far wider community whom the laws of the tides nearly interest, by giving a connected and tolerably elementary view of Laplace's investigation, which he states confidently to be "the most obscure of the *Mécanique Céleste*."

(74.) Its incompleteness.

In this theory the figure of the ocean at any moment is considered as a dynamical problem; and that figure as a momentary state arising from the internal movements of the fluid itself, as well as from the variation of the external forces. The resulting differential equations, expressing the attractions of the sun, moon, and earth, the rotatory movement of the earth, and the pressure of the water itself in motion, are abundantly complex, and the solutions only partial and imperfect. The inferences from these solutions, too, partake not only of their imperfection, but, since they take no cognisance of the irregular distribution of land and water, present cases almost impossible to verify by observation. Some of the results are indeed so paradoxical, that without better evidence of their truth we do not further allude to them.

(75.) Three classes of Tides.

The tidal effects are divided by Laplace into three classes; the distinction of which, however, cannot be called a discovery of his. The *first* class are independent of the earth's rotation, and are practically insignificant. The *second* class includes the diurnal tide occurring once in about 24 hours. Concerning it, Laplace draws this conclusion, that its rise and fall (not, however, its horizontal motion) are insensible if the depth of the ocean is uniform;[1] and being practically insensible in most latitudes, we have thence an argument of more or less weight for a general tendency to uniformity in the depth of the sea. The *third class* of tides are the ordinary semi-diurnal tides. They afford, as Newton acutely perceived, the most direct and attainable measure of the relative attractions of the sun and moon. We have the sum of these attractions at the conjunctions and oppositions of the luminaries, and the difference when they are 90° apart; and a higher maximum when both bodies are without latitude. From the observation of the tides on the Severn near Bristol, Newton computed the relative action of the moon and sun to be as 4·48 to 1; but this value is much too great, and gave far too large a relative mass to the moon. The result in the harbour of Brest, from observations made under Laplace's direction, is about 2·90 to 1; and the moon's mass $\frac{1}{75}$th that of the earth, agreeing almost identically with that deduced from the nutation of the earth's axis caused by her attraction. Observations at London and Liverpool reduced by Sir John Lubbock and Dr Whewell give about 2·66 to 1.[2]

(76.) Laplace's results.

From the general theory of Laplace, the following results have been deduced with confidence:—(1.) That the stability of the ocean is secure, whilst the density of the ocean is inferior to that of the earth generally; which it is about five or six times. (2.) That the phenomenon of precession is not modified by the fluid covering of the globe.

(77.)

In the application of his theory to special cases, Laplace is compelled to have recourse to an assumption entirely arbitrary—namely, that the periodic fluctuations, however otherwise modified by circumstances, recur in the same periods as the causes to which they are due. In this manner he *conciliates* the results of observation with his theory, which the latter would have been altogether incompetent to *predict*.

(78.) Character of Laplace's investigation.

The general merits of Laplace's theory we will sum up in the words of Mr Airy, who, of all his successors, has probably most attentively studied it:—"If, putting from our thoughts the details of the investigation, we consider its general plan and objects, we must allow it to be one of the most splendid works of the greatest mathematician of the past age. To appreciate this, the reader must consider—first, the boldness of the writer who, having a clear understanding of the gross imperfection of the methods of his predecessors, had also the courage deliberately to take up the problem on grounds fundamentally correct (however it might be limited by suppositions afterwards introduced); secondly, the general difficulty of treating the motions of fluids; thirdly, the peculiar difficulty of treating the motions when the fluids cover an area which is not plane but convex; and, fourthly, the sagacity of perceiving that it was necessary to consider the earth as a revolving body, and the skill of correctly introducing this consideration. The last point alone, in our opinion, gives a greater claim for reputation than the boasted explanation of the long inequality of Jupiter and Saturn." [1] We must, however, qualify this eulogy by adding, in the words of the same writer, that Laplace's theory, though based on sounder principles than the equilibrium theory, "has far too little regard to the actual state of the earth to serve for the explanation of even the principal phenomena of the tides." It is, in fact, like many other productions of the same age and school, a great display of ingenuity and mathematical skill, which hardly yields a single result worthy of confidence, or agreeing with nature, except by the abandonment of its deductive rigour, or a concealed induction backwards from the phenomena to be accounted for. The same amount of skill and resource which Mr Airy has shown in adapting it to his own views, and to recent observations, would probably have sufficed to construct a theory from the foundation. By others the attempt seems to have been abandoned as hopeless.

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[1] Dr Young asserts that the conclusion will not hold unless the depth be also evanescent. Laplace has shown in his Fifth Book that the disappearance of diurnal tides will take place only when the nucleus is completely covered.

[2] These ratios, however, being found to depend upon the configuration of the coast or estuary, cannot be used *directly* to determine the relative action of the sun and moon. See *Phil. Trans.*, 1845, p. 42.

(79.) Laws of Tides.—Dr Whewell—Sir J. Lubbock.

Since our limits will not permit us to return to the subject of tides, we shall here briefly state the progress of the subject since the time of Laplace. The chief steps have consisted in co-ordinating the results of observation and analyzing them into their partial phenomena, by the help of Newton's and Bernouilli's theory. This labour has been greatly advanced by Dr Whewell, and also by Sir John Lubbock. The former has constructed maps of "cotidal lines," which, indicating the relative time of high water in different parts of the globe, give us a graphic conception of the course and propagation of the tidal wave. The tides of the Eastern Pacific are but little known; but a vast wave advances northwards between Australia and Africa, diverted or retarded by the obstacles it meets with in the Indian Archipelago. Another (and to us the most important) branch sets from south to north up the vast canal of the Atlantic, where it is gradually complicated by local tides, having their origin in the wide expanse between Africa and the Gulf of Mexico. The two sets of waves sometimes reinforce, sometimes oppose, one another; they are prolonged to the western shores of England and Norway, where the tidal impulse arrives 24 hours after it passed the Cape of Good Hope. It is propagated most rapidly at a distance from coasts, and is retarded in narrows and shallows. It sends offshoots into every bay and strait, always greatly retarded in point of time (apparently by friction), but often increased in elevation by concentration of the effect in a gradually narrowing channel, as we see in the exaggerated tides of the river Amazon, the Severn, and the Bay of Fundy. The same place may be the seat of several tides at once, which may increase or destroy one another; thus, a small tide is propagated through the Straits of Dover as far as the Dutch coast, where it only arrives simultaneously with the principal wave, which has made the entire tour of Great Britain.

Cotidal lines.

(80.) Theory of Dr Young.

As regards the progress of theory, Dr Thomas Young, whose character as one of the greatest philosophers of the past age we shall have to consider in another chapter, next after Laplace grappled with the difficulties of this arduous subject. Employing mathematical methods of inferior power but greater directness, and taking into account causes of local action which Laplace had not ventured to include in his analysis, he gradually matured a theory adequate to represent many of the results of experience, of which Laplace gives no account.

(81.) Free and forced waves.

He distinguishes the results of the *forced* and *free* oscillations of the sea; the former resulting from the direct action of the sun and moon combined with the rotation of the earth, and whose periods of rise and fall are determined solely by those external causes (external, I mean, to the mass of the ocean); the *free* waves, on the contrary, derived from the former, are transmitted with velocities depending on the mechanism of the fluid itself, on its depth, and on the resistances arising from friction to which those motions are exposed. These all-important modifications of the dynamical Theory of the Tides were deduced by Dr Young from the general theory of oscillations and resistances, and from the laws of fluids detected by Dubuat,[2] and he applied them with no ordinary skill to the solution of the problems of tides in oceans, estuaries, and rivers. It is an extraordinary fact, and not without significance, in the history of science, that these researches of Young, published anonymously in the Supplement to the Sixth Edition of the Encyclopædia Britannica, and in the Seventh Edition of this work, and likewise in several journals and reviews, so generally escaped notice as to have been almost unknown till Dr Peacock, in his recently published "Life and Miscellaneous Works of Dr Thomas Young" has fortunately recalled attention to their existence and their important results.

(82.) Mr Airy on Tides and Waves.

In doing so, Dr Peacock has communicated with Mr Airy, whose very valuable article on *Tides and Waves* has been above referred to (78), and has ascertained from him that Dr Young's researches had escaped his notice when he undertook that elaborate recension of Laplace's theory, and made those important additions to it to which I have called attention.[1] It is very satisfactory to find that, by their independent and very different modes of analysis, Mr Airy and Dr Young have arrived at results generally coincident. It is in the essay of the former that most readers will now seek for an acquaintance with Laplace's abstruse investigations, whilst they will find in it the bearing of experiments more recent than the time of Young on the propagation of waves in canals, the theory of Mr Airy, beginning as it were at the opposite end from that of Laplace, and offering far more points of contact with actual observation, particularly in the Tides of Rivers and Estuaries. The theory of Young will naturally be best studied in his own article TIDES, in this Encyclopædia.

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[1] *Encyclopædia Metropolitana,* "Tides and Waves," art. 117.

[2] See Chapter IV., Section 6, where we shall return to some portion of this subject.

(83.) Doctrine of Probabilities.

IV. In the fourth place, we connect the name of Laplace with the progress, during the period we are considering, of the curious doctrine of probability, or the laws of chance and expectation. These he discussed in two works, the *Théorie Analytique* and the *Essai Philosophique sur les Probabilités*—the first the most mathematically profound, the last the most popular and elegant, account of the subject which has yet been given. Nearly all mathematicians are agreed on two points—*first*, in considering this the "most subtle" and "difficult to handle" of all the applications of their science, involving a perpetual recurrence to *contingencies*, and to elements of the argument easily left out of account, and in which, more than in any other, it is dangerous to let sleep for a moment the severely reasoning faculty, or permit it to be lulled to security amidst the maze of symbolic transformation. In truth, from experience, I am disposed to receive with doubt the solution of even a tolerably simple problem of chances, unless two competent persons at least have concurred in verifying it. *Secondly*, Mathematicians are agreed in considering Laplace's *Théorie* nearly, if not quite, the ablest specimen of mathematical writing of his age, notwithstanding a degree of obscurity and repetition in addition to the inherent abstruseness of the subject, which render it, in the opinion of one of the most learned and extensively read of our pure mathematicians,[2] "by very much the most difficult mathematical work he ever met with."

(84.) Improvements in its investigation by Laplace.

A single paragraph has been devoted to the subject of probabilities in Sir John Leslie's Dissertation, relating to its earlier history; and the subject was so popular during the last century, that there was scarcely an eminent mathematician who did not add something to its practical development; so that Laplace may be considered rather to have enlarged widely its applications by means of his almost unexampled power in handling the calculus, than to have improved or established its first principles, or even applied it to classes of problems altogether new. We find that most of the principles of the Calculus were established by James Bernouilli, in the earliest part of the eighteenth century, who gave the first application of the Binomial Theorem to determine the probability of a particular combination of a given number of things occurring, in preference to all the other equally possible combinations. Stirling discovered a curious theorem for approximating to the continued product of the arithmetical series of numbers carried to any extent, which perpetually occurs in such calculations. Demoivre carried out Halley's application of it to the laws of mortality. Condorcet applied it to moral questions; Mitchell to natural phenomena, considered as the results of accident or design; Lagrange to errors of observation. The chief applications of the Theory of Probability are the following:—1. To chances known *à priori*, as that of throwing two given numbers with dice, the whole range of possibilities being known with precision. 2. The calculation of the *expectation* of future events on a great or average scale, deduced from the past course of events observed also on a great or average scale. Of this description are the calculations of life assurance, first tabulated by Halley. 3. To find the most probable result of a number of independent observations and problems of a like kind. 4. To the proof of *causation* as opposed to accident or "random," derived from existing combinations of facts. 5. To the probability of testimony, and the confidence due to legal decisions. None of these inquiries are *peculiar* to Laplace, or originated with him. We select, however, for a brief notice (which must be confined to a few sentences) the third and fourth of these applications.

History of the Doctrine of Chances.

Its chief applications.

(85.) To find the most probable result of a number of independent observations.

The chances are enormous against the most experienced marksman's hitting the bull's eye of a target. But if he make many shots in succession, the balls will be lodged round about the spot at which he aimed, and they will be fewer in each successive ring of equal area drawn round the mark. The degree of their scattering will depend upon the skill of the marksman; but in all cases the most probable result will be, that the point aimed at is the *centre of gravity* of the shots. This may be shown to be equivalent to saying that *the most probable result of any number of equally reliable observations is that which will make the sum of the squares of the outstanding errors a minimum*. This rule was conjecturally proposed by Legendre in 1806. A demonstration of its truth was first published by Laplace. It is of great practical use in deducing the results of complex observations, such as those of Astronomy, and generally in combining "equations of condition" more numerous than the quantities whose value is sought to be extracted from them. In very many cases, however, a graphical

Legendre's method of least squares.

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[1] See note to p. 262 of the Second Volume of "Young's Miscellaneous Works," by Peacock.

[2] Professor De Morgan in *Encyclopædia Metropolitana*.

method of interpolation will serve the same purpose, as well as save a very tedious calculation. Perhaps too much importance has been assigned to the "probable mean error" of a single observation deduced from many individual errors by the same theory. If a man has but one shot at a target, it is perfectly uncertain (by hypothesis) whether that shot be one of his best, or one of his worst, or one of his middling ones. But as there are more middling hits than very bad or very good ones, there is a certain distance which it will be safe to bet (*i. e.* for which the probability is $\frac{1}{2}$), that he will not exceed; though it would be a strange occurrence indeed, if he exactly struck the ring in question. This is all that is meant by the phrase "probable error;" it is an entirely artificial number, which serves to give a sort of numerical value of the skill of the performer, but is otherwise of no importance. Its application has sometimes been strangely mistaken. Even the "rule of least squares" is often misapplied, and empirical laws altogether false have been deduced from it; for it is rare in practice that the chances of error of observation of a varying quantity are the same throughout the limits of observation.

Probable error.

(86.) Probability of Testimony and of Design.

But those applications of the doctrine of probability which pretend to give us a measure of our belief in the constancy of natural laws, in the confidence due to testimony and to the teachings of history, in the proofs of design in cosmical arrangements,—are inquiries which, from their connection with metaphysics, religion, and morals, have had a higher interest for mankind at large than ordinary problems about cards and dice. To these Laplace paid peculiar attention; and the reputation of his name tended to create in others a belief that the analysis he so powerfully wielded could communicate a portion of its certainty to the data subjected to it, and gave a currency to many of his conclusions to which we believe them by no means entitled. Professor Playfair, one of the most ardent of Laplace's admirers, has recorded (in a criticism in the *Edinburgh Review*, of the works we are considering) his total dissent from Laplace's doctrine that the transmission from age to age of the historic record of a fact diminishes its credibility in a geometrical ratio. But a Cambridge mathematician and speculative philosopher of singular penetration, Mr Leslie Ellis, has most formally assailed[1] the principle of nearly all Laplace's estimates of our expectation of events arising from causes unknown or assumed to be so, such, for instance, as that a common cause determined the revolution of all the planets in one direction. The subject of the metaphysics of probability evidently requires a complete reconsideration; and, owing to the singular subtlety of the matter, it is one which few persons are competent to handle. The state of health of Mr Ellis leaves us little hope of his resuming the inquiry; but two eminent mathematicians, Mr De Morgan and Mr Boole, have published considerable works chiefly bearing upon it.

Laplace's doctrines questioned.

(87.) Probability as a guide to discovery.

As an implement bearing upon discovery in science, the Calculus of Probabilities has as yet been of little service. Whilst Laplace tries to indicate how it guided his researches connected with planetary irregularities, every one sees at a glance that, with the data before him, common sense must have outstripped analysis. Laplace has called the doctrines of probability "good sense reduced to calculation." What is to be feared is, that the calculation should outstrip the good sense.

(88.) Laplace's character as a physicist, and as an author.

V. Fifthly, We are to consider Laplace's character as a general physicist and as a writer.

In the former respect he stands in a higher position than that usually attained by eminent analysts. In fact, if we compare him with any of his own generation, we find him not only better acquainted with physical principles, and more scrupulous in taking account of them in his mathematical discussions, but even possessing skill and interest in experiments. The Calorimeter for measuring the capacities of bodies for heat was the joint invention of Lavoisier and himself; at least their memoir does not assign to either a predominant share in it,[2] and their determinations of the expansions of the metals by heat seem also to have been made in common. His happy discovery of the chief or sole cause of the discrepancy between the theoretical and observed velocity of sound (due to the heat developed by compression) would alone have given him a just reputation, so anxiously had the matter been debated, and so much was it involved in a purely mathematical intricacy. Even in his great work on physical astronomy he takes a peculiar pleasure in embracing topics of terrestrial physics. We there find discussed the theory of barometrical measurements, the question of atmospheric tides, the laws of capillary attraction, and the constitution of the gases. As to the first of these topics he made a practical improvement on the formulæ of his predecessors, so that his rules are in fact still in use. As regards capillary attraction, he was materially anticipated by Young, who evidently considered his principles to have been pirated; yet his theory, though obscured by a display of redundant mathematics, was a real improvement. His theory of tides, and that of atmospheric refractions, though closely connected with physical astronomy, were in fact not less so with the doctrines of hydro-

Memoirs on Heat, in common with Lavoisier.

On Barometrical Measurements, Capillary Attraction, & Astronomical Refractions.

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[1] Cambridge Transactions, Vol. VIII. The writer of these pages has also given his reasons for dissenting from the arguments of Michell (which have been sanctioned by the authority of Laplace) on an astronomical question as discussed by the Theory of Probabilities. See *Philosophical Magazine* for December 1850.

[2] Dr Black, the discoverer of latent heat (who was probably well-informed), states in a letter to Watt that he believes Laplace to have been the inventor. See *Correspondence of Watt on the Decomposition of Water*, p. 66.

dynamics and optics; and we shall find very few important branches of general physics in which he has not left some permanent record of his interest, in the course of his career of *fifty-five* years of anxious devotion to science.

(89.) His *Traité de Mécanique Céleste.* Far less original than the *Principia;* yet gives him justly a high reputation.

His largest and most systematic work, the *Traité de Mécanique Céleste*, in five quarto volumes, was not only most ably executed, but exceedingly well timed. The applications of analysis to physical astronomy had been accumulating for nearly a century. Hundreds of memoirs relating to them, dispersed through many volumes in different languages, written with varying ability, in various stages of scientific progress, and with differing notations, presented a mass of reading almost beyond the reach of the most resolute student. Laplace undertook to digest the whole into one body of doctrine, composed throughout on a uniform plan, with the best mathematical aids which were known at the commencement of this century. And though improvements and discoveries have been since made, the methods and most of the results of the *Mécanique Céleste* remain, with little variation, the preferable ones of our own time. As a work of labour, it may compete with the *Principia* of Newton; as an original work, it is of course immeasurably inferior. Its *principles* are, in fact, the same with those laid down in that immortal code, and its deductions are collected (as we have said) from the writings of Clairaut, D'Alembert, Euler, and Lagrange, as well as from the previous memoirs of the author himself. Laplace has been too sparing of his citations and acknowledgments, and a consequence of this literary avarice has been that he is sometimes considered as more of a compiler and less of a discoverer than is justly his due. For however ill he could have dispensed with the skilful preparations of his illustrious rivals and contemporaries, his preeminent sagacity furnished on several occasions the key-stone of the arch which imparted at once strength and completeness to the fabric. We have seen in the last section that though the credit of the theorems respecting the stability of the solar system is very generally attributed to Lagrange, who, indeed, principally furnished the methods, and gave great generality to the results, yet the capital discovery of the invariability of the major axes of the planetary orbits is due to Laplace. It was he, again, who removed from the theory of gravity the two greatest and most impracticable difficulties with which it had ever been assailed—the anomaly of the lunar accelerations, and the great inequalities of Jupiter and Saturn, and by so doing rendered it almost infinitely improbable that any future discrepancy should more than temporarily embarrass a theory which had triumphed in succession over such formidable causes of doubt. True that Lagrange, in his memoir of 1783, had come within a single step of the first of these discoveries, and, by a process of exclusion, had almost forced attention in the right direction respecting the latter; still Laplace seized the prize in both cases, after a fair, prolonged, and arduous struggle. Now these three discoveries were the greatest in physical astronomy between those of D'Alembert and Clairaut on the precession of the equinoxes, the motion of the lunar apse, and the periodicity of comets,—and that of Leverrier and Adams on the perturbations of Uranus about a century later.

(90.) Laplace compared with Lagrange.

The universal testimony of mathematicians is to the effect that Lagrange was unrivalled as a pure analyst, in his power of generalization, and in the inherent elegance of his methods; that Laplace, with nearly equal power in using the calculus, had more sagacity in its mechanical and astronomical applications, or rather, perhaps, we should say, in directing it to the discrimination of causes, and the revelation of consequences.

(91.) His public character. and as a Member of the Academy of Sciences.

In other respects he differed far more widely from his illustrious compeer. He rather courted popularity, and was pleased at being considered worthy of political distinction. For a short time he was one of Napoleon's ministers; but the Emperor, it is said, was more satisfied with his mathematical than with his diplomatic talents. He had none of the shyness of Lagrange, nor his repugnance to general society. He received with affability and kindness those who were introduced to him, and his attentions were afterwards recollected with gratitude by rising men of science abroad. He had a villa at Arceuil, adjoining that of Berthollet, and was one of the original members of the "Societé d'Arceuil," to whose memoirs he contributed. He exercised a powerful influence in the Academy of Sciences, of which for a time he acted as dictator, and he was not very tolerant of views in science opposed to his own. The undulatory theory of light he always opposed, and was mainly determined in doing so by the facility with which the attraction of luminous corpuscles could be subjected to calculation.

(92.) Love of analytical display.

The weak point of his scientific character was one so natural, and perhaps so inseparable from his prevailing studies, that it is not fair to criticise it too severely. This was a love of analytical display in treating questions which it rather embarrassed than illustrated; and generally, a disposition to overrate the sphere of mathematical discovery. This he had in common with Euler, to whom he was very superior in physical attainments and sagacity. His language, and that of his eulogists,[1] often amounts to the assumption that the marvellous power of analysis, in unravelling intricate consequences of admitted or assumed laws, could supply deficiencies of primary conceptions of the laws of nature, or could teach men fundamental truths in natural science.

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[1] For instance Arago says (speaking of the invariability of the major axes): "Enfin par la toute-puissance d'une formule mathèmatique, le monde materiel se trouva raffermi sur ses fondements" (*Annuaire*, 1844, p. 304). This is indeed the *idolatry* of mathematics. Many examples may be found in Laplace's writings on Probability; which occasioned Mr Ellis to say of him, that "to Laplace all the lessons of History were merely confirmations of the 'resultats de calcul.'" To the same effect was the *mot* of Napoleon, "that Laplace carried into the art of government the principles of the infinitesimal calculus."

(93.) His *Système du Monde.* To add to the remarkable list of Laplace's endowments one more; he was a perspicuous and elegant writer. His *Système du Monde* contains a popular exposition of astronomy in theory and practice entirely original in its plan and execution, and though frequently imitated, it is still perhaps the first of its class.

(94.) Date of birth and death. Laplace was born in Normandy 23d March 1749, and died the 5th May 1827, leaving in the Academy he had so long honoured no one within many degrees of his ability in the same peculiar walk of science.

§ 3. Legendre.—Ivory.—*Theory of Integration; Elliptic Transcendants* (Abel, Jacobi). *The Attraction of Spheroids, and Theory of the Earth's Figure. Atmospherical Refractions.*

(95.) Legendre. Adrien Marie Legendre was born in France in 1752, and died in 1833 (10th January); he was consequently three years younger than Laplace, and survived him by nearly six years. He formed, therefore, an integral part of that constellation of mathematical talent of which Paris was for more than two generations the main centre. Like his illustrious compeers Lagrange and Laplace, he laboured with enthusiasm all the days of his life, and like them was engaged in editing and improving his works down almost to the day of his death, at the ripe age of fourscore.

(96.) Distinguished as an able mathematician. The mathematical career of Legendre was less splendid than that of the other two whom we have just mentioned. He did not possess the wonderful powers of generalization of Lagrange, and he wanted the flexibility of mind, and the general physical knowledge, of Laplace. Legendre was very strictly a mathematician; and he has been exceeded by none in the unquenchable zeal with which he pursued subjects of a dry and even repulsive character, often till he had hunted them down by sheer force of application, or, to adopt the metaphor applied to him by Lagrange, until he carried, sword in hand, the stronghold which he besieged.

(97.) His researches on Elliptic Functions. No more striking proof can be given of these statements than the unflinching pertinacity with which, during nearly fifty years (1786–1833), he studied and improved the theory of Integration, applicable to those cases frequently occurring, which involve the higher powers of the independent variable, and which do not usually admit of finite expression. Two large works, the *Exercises du Calcul Integral* (1811), and the *Traité des Fonctions Elliptiques* (1827–32),—the latter in good measure a republication of the materials of the former,—bear testimony to his diligence; and these works were almost entirely original, and contained tables of most laboured construction, calculated by himself. Hardly any mathematician entered into competition or co-operation with him until his labours were drawing to a close, when, with a liberality worthy of all commendation, he welcomed the analytical discoveries of Abel and Jacobi, which were to give an unlooked-for extension to his own. These methods of integration, and their reference to certain properties of the Lemniscate and the Ellipse, originated in the early part of the last century with Fagnano and Euler. Legendre took up the subject exactly where Euler left it, and finally reduced the large class of expressions to which his methods are applicable to three standard forms or integrals in which the independent variable is always expressed by a circular function, and to which a numerical approximation may always be made by means of the tables calculated by himself.

(98.) Abel's discoveries on the same subject; his personal history. Abel, who succeeded in generalizing Legendre's methods to a far greater extent, was a native of Norway, born in 1802 (25th August),[1] and died at the premature age of twenty-six (1829, 26th April). His principal memoir was presented to the Institute when he was only twenty-four years old; and, to use the language of Mr Leslie Ellis, "when the resources of the integral calculus were apparently exhausted, Abel was enabled to pass into new fields of research by bringing it into intimate connection with a new branch of analysis, namely the Theory of Equations. The manner in which this was done shows that he was not unworthy to follow in the path of Euler and of Lagrange."[2] Legendre's eulogy of Abel was concise:—"Quelle tête celle du jeune Norvegien!" It is less agreeable to add that the life of Abel was perhaps shortened by poverty and care. Though ultimately befriended by Legendre, Poisson, and others, his first visit to Paris (in 1826) occasioned nothing but disappointment, and his great memoir (no unusual lot, for the same happened to Fresnel) lay hopelessly lost amidst the papers of the Institute for fifteen years. Much, however, to their credit, the geometers above mentioned at length addressed the King of Sweden on behalf of the rare genius his dominions contained; but in vain. Abel died neglected, unable even to print his researches, which were tardily given to the world in a collected form, at the expense of the government which refused to support him when alive. The French Academy, which had buried his memoir in their most inaccessible "archives," decreed too late the unprecedented honour of a posthumous medal to his mother. Jacobi, the friendly rival of Abel in his discoveries, died recently, at a mature though not advanced age, at Königsberg, where he was professor.

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[1] There is some discrepancy, as to the *year* of his birth, but I believe this to be correct.

[2] Report on the recent progress of Analysis. British Association Report for 1846.

(99.) Legendre's researches on the attraction of Ellipsoids,

But to return to the labours of Legendre. The theory of the figure and attraction of the earth and of other planets naturally divides itself into two parts—(1.) the law of attraction of an ellipsoid on a material point without or within it; (2.) the figure of equilibrium of a fluid subjected to no forces but the mutual attractions of its particles, and the centrifugal force due to its rotation. The latter of these problems is still imperfectly solved, the former completely so, and that mainly in consequence of the labours of Legendre and Ivory.[1]

(100.) sometimes in part attributed to Laplace.

Though the services of Legendre are well known and admitted, the superior address of Laplace in the applications of mathematics has occasioned his receiving the credit of what in some instances belonged to the former.

(101.) History of the subject.

Maclaurin, by an exercise of synthetic skill not exceeded since the death of Newton, had demonstrated the attraction of an ellipsoid of revolution upon a material point anywhere *within* it or on its *surface*, as well as for an exterior point in the prolongation of its axis or in the plane of its equator. The same problem was afterwards analytically solved by D'Alembert and Lagrange. In 1782, Legendre, by a profound and complicated analysis, obtained an expression, by means of series, for the attraction of an exterior particle generally, and he was the first to imagine and employ those artifices of calculation known usually by the name of "Laplace's functions." Laplace made a step towards the simplification of the expression of exterior attractions, but the complete solution was reserved for Mr Ivory, as I shall mention below.

(102.) Other works.

The other labours of Legendre need not be specified here. He co-operated in the trigonometrical survey of France, and gave the formula, known by his name, for approximately reducing a spherical to a plane triangle. He also wrote on the orbits of comets, and on the method of least squares.

(103.) Ivory.

James Ivory, the most considerable British mathematician of his time, or that had appeared since Maclaurin, was born at Dundee in 1765, and studied at St Andrews along with Sir John Leslie. The most active period of his life was passed as mathematical professor at the Military College of Marlow (afterwards removed to Sandhurst). He was essentially a self-taught mathematician, and spent much of his time in retirement. He fathomed in private the profoundest writings of the most learned continental mathematicians, and, at a period when but few Englishmen were able to understand those difficult works, he showed his capacity of adding to their value by original contributions, not unworthy of the first analysts. We pass over his earlier contributions connected with mathematics and astronomy, several of which are contained in the Transactions of the Royal Society of Edinburgh, and proceed to his most celebrated paper, published in the Philosophical Transactions for 1809, in which he completely and definitely resolves the problem of attractions for every class of ellipsoidal bodies. After what has been stated above as to the position of the problem as treated by Legendre, a few words will explain the precise import of *Ivory's Theorem*, one of the most celebrated mathematical results of that time.

(104.) His important Theorem on the attraction of Ellipsoids.

We have seen that the attraction of an ellipsoid on a point *within* or *at* its surface had been assigned by Maclaurin. The theorem in question enables us at once to reduce the case of an *exterior* attracted point to that of a point *on* the surface of the ellipsoid. Suppose an ellipsoid having the same excentricity, and with the principal sections parallel to the first, but whose surface passes through the given exterior point. Let points on the surface whose co-ordinates parallel to the three axes of the respective solids are proportional to those axes be called *corresponding points;* then the attraction parallel to each axis which one of these bodies exerts on a point situated on the surface of the other is to the attraction of the latter on the "corresponding point" of the surface of the former, as the product of the two other axes of the first ellipsoid is to the product of the two other axes of the second. By this means the attraction on an exterior point is accurately expressed in terms of the attraction on an interior point, which is known. It is fair to add that both Legendre and Laplace had some glimpses of the principle, though they failed to apply it to the direct solution of the problem, and between the publication of their Memoirs and that of Mr Ivory there elapsed nearly a quarter of a century.

(105.) His other Papers.

Besides this paper, Ivory contributed many others on the subject of the attraction of spheroids and the theory of the figure of the earth, during a period of nearly thirty years; several of these were controversial, and did not add materially to the progress of the subject; others are considered as masterpieces of analytical skill. One of the last subjects which occupied his attention was the possible equilibrium of a spheroid with three unequal axes, which Jacobi had discovered.

(106.)

Between the labours of Ivory and those of Legendre a great analogy subsists; for the doctrine of elliptic integrals also occupied the attention of the former.

(107.) Atmospheric Refraction.

But next to the theory of attractions, that of *Atmospheric Refraction* most seriously engaged Ivory's attention. Its great importance in astronomy, and the curious mathematical difficulties which it presents, renders it very interesting to analysts. Laplace had applied to it his method of Generating Functions; Kramp had introduced into his (now scarce) treatise the almost new Calculus of Factorials; and others, like Bessel and Atkinson, had skilfully combined theory and observation for the construction of useful tables. One of the most curious results of recent enquiries into this subject is, that Sir Isaac Newton's table of refractions (*Phil. Trans.*, 1721) must have been founded on a profound consideration of the problem, such as no one else thought of till a much later period, and is so numerically exact as to agree closely with the later tables, Kramp's for example.[1]

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[1] See the articles Attraction and Figure of the Earth (the former by Ivory) in this Encyclopædia.

(108.) His death. Mr Ivory attained the age of seventy-seven, dying on the 21st September 1842. Probably his unceasing devotion to a confined and abstruse topic of enquiry, reacting on a sensitive frame, rendered him in some degree irritable and unsocial. He was not altogether responsible for this; but students of science should recollect that diversity of occupations and interests is subservient not only to bodily health, but also to mental equanimity and vigour.

(109.) His eminent position as a British Mathematician. The historian of science dwells with a special interest on the results of Ivory's labours, when we recal the singular destitution of higher mathematical talent which had reigned in this country for so long a period, and which left us not only no position in the great struggle going on abroad for the advancement of physical astronomy, but scarcely even the rank of intelligent spectators.

§ 4. *Progress of Physical Astronomy since the publication of the Mécanique Céleste.*—Poisson.—*Theory of Rotation* (Poinsot).—Mr Airy—*The Solar Theory.*—MM. Plana *and* Hansen—*The Lunar Theory.*—*Physical Astronomy in America.*

(110.) Increasing difficulty of physical astronomy. The more that any theory of a mathematical kind, like that of Gravitation, advances to perfection, the less reason have we to expect great and striking results in the prosecution of it, and the more intense and continuous is the labour in matters of detail necessary to make any advance at all.

(111.) Its progress since the publication of the *Mécanique Céleste.* As regards the general and popular view of the subject, we might pass at once from the epoch of Lagrange and Laplace to that of Leverrier and Adams. Notwithstanding, however, the necessity of extreme compression, I must devote one short section to mentioning the chief labours in connection with physical astronomy of four eminent men mentioned in our title, who may fitly be considered as the immediate successors of Laplace. Two of them will be again referred to in this discourse.

(112.) Poisson. Simeon Denis Poisson, born in 1781, may be said truly to have been brought up at the feet of Lagrange and Laplace. He was their pupil in the first and brightest years of the Polytechnic School, where he was especially noticed by the former. He had the distinguished privilege of being literally their fellow-worker, his early memoirs having reference to their labours, and stimulating the still vigorous mind of Lagrange to the production, in his latest years, of several memoirs, which have been considered worthy of his best days. on the stability of the system; I refer more particularly to Poisson's proof that the stability of the planetary system holds when perturbations of the second order are taken into account, as has been stated in the first section of this chapter, Art. (55.) This was in 1808. on Rotation; Soon after, following out another of Lagrange's admirable generalizations of his theory of Arbitrary Constants, he embraced in a common series of formulæ the result of those mechanical laws which regulate the *rotation* of bodies, together with those concerned in their *translation* in space. This important subject (rotation) continued at intervals to engage the attention of Poisson, not only as regards the motions of the heavenly bodies on their axes, but also as a branch of common mechanics. The basis of this intricate doctrine was laid by Huygens; Euler, in a celebrated and original work, gave it a general and analytical form; D'Alembert solved by it the problems of precession and nutation; Laplace demonstrated the constancy of the time of the earth's rotation round its axis. This last problem was more fully discussed by Poisson, who showed by theory that neither can the earth ever rotate round an axis different from its present one, nor can the time of its rotation vary in consequence of any external attractions to which it is subject. These two matters are of the utmost moment; the first prevents the latitude of places from varying, and also renders impossible the extensive flooding of dry land by the waters of the ocean, which would be the evident consequence of such a change; invariability of the mean solar day. the second assures us that the grand unit of reckoning in all ages, the basis of astronomical chronology and of physical astronomy generally, *the length of the mean solar day*, has not varied, and never will perceptibly vary under the action of known forces. Laplace had long before proved, by a comparison of ancient eclipses with modern observations, that, practically, the length of the day had not varied in 2000 years. It appears, indeed, that since the earliest recorded Chaldean eclipse (that of B.C. 720), the rotatory velocity has not altered by one *ten-millionth* part.

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[1] See Biot in *Connaissance des Temps*, 1839; and Baily's *Life of Flamsteed.*

(113.) M. Poinsot on Rotation.

An eminent contemporary and rival of Poisson, M. Poinsot, has added many elegant propositions to the Theory of Rotation. M. Poinsot is also the author of the Theory of *Statical Couples*, which now forms part of all elementary treatises on mechanics.

(114.) Other writings of Poisson.

Poisson wrote many other papers on subjects of physical astronomy, such, for example, as the Lunar Theory, but they did not lead, on the whole, to striking conclusions. In fact, he allowed himself to be diverted from this his most natural calling, by the ambition of constructing a system of Physics mainly founded on the applications of analysis. Some bulky volumes of this series appeared, especially those on Capillary Attraction, and on the Theory of Heat. The author here shows himself as a profound analyst, but adds little to our knowledge either of principles or of important results. A similar criticism may be applied to his theory of Elastic Substances, and to his doctrine of Waves. His papers on Magnetism and Electricity will be mentioned elsewhere, but their character is somewhat similar. In Optics he was attached to the Newtonian theory. In Mechanics not requiring assumptions as to the properties of matter, he was very successful. He was eminently a solver of hard problems: his investigation of the whole circumstances of motion of a projectile in air deserves notice. Indeed every branch of mechanics received his attention, and the number of his printed papers is said to exceed three hundred. On the whole, he will, perhaps, be most generally and favourably known by the excellent Treatise on Mechanics which he wrote for the use of advanced students. He was an eminent and diligent Professor, and his whole life was one of almost unremitting study. "*La vie c'est le travail*" was his reply, when urged to consult his health by reposing from his labours: and he actually died in the discharge of his duty as examinator of the Polytechnic School. This occurred on the 25th April 1840, in the fifty-ninth year of his age.

His Treatise on Mechanics.

(115.) Mr Airy on the perturbation of the Earth by Venus.

Mr Airy *on the perturbation by Venus of the Earth's motion.*—We here detach from what we shall elsewhere have to record of the eminent services rendered to the cause of astronomy by the present Astronomer Royal of England, a notice of his chief discovery in physical astronomy, the more remarkable from being almost the only improvement in the *theory* of the planetary motions, as applicable to the tables, which had proceeded from an English mathematician for a very long period. Sir James South called attention, in 1826, to a small but well marked deviation of the Sun's place from that given by Delambre's solar theory (the Sun's place or the Earth's are of course convertible terms). Mr Airy, then Lucasian professor at Cambridge, instituted, in 1827, a more extensive comparison with the Greenwich Observations, and attributed the error chiefly to the assumption of erroneous masses for Venus and Mars. But prolonged study satisfied him that it arose from a "long inequality," arising from the mutual action of the Earth and Venus, similar in its nature to that mentioned in Art. (66), as detected by Laplace in the case of Jupiter and Saturn. It arises from the circumstance that eight times the orbital period of the Earth is almost equivalent to thirteen times that of Venus. Terms of the series expressive of the mutual action of the planets, which are divided by thirteen times the mean motion of the former *minus* eight times the mean motion of the latter (which is a very small quantity), may consequently become considerable; still more, those involving the square of this quantity. Such terms belong to the fifth and higher orders of the excentricity, and would consequently be very minute indeed, but for the casual magnitude of their coefficient. The labour of tracing out and calculating the effects of these important terms from the vast mass of algebraic developments is enormously great,—much greater than in the corresponding case of Jupiter and Saturn. As the calculations are not very likely to be repeated, Mr Airy took extraordinary precautions in their verification. The period of the inequality depends, first, as has been explained in Art. (67), upon the period required to carry the point of conjunction of the two planets completely round the circumference. This period is no less than 270 years. The perturbation is of course mutual, and affects the place of Venus as well as of the Earth.

Mr Airy is also the author of investigations connected with the Figure of the Earth, and the Theory of the Tides [see Art. (82)]; and he has published valuable Tracts on Physical Astronomy for the use of students. (116.)

(117.) Sir John Lubbock.

Sir John Lubbock's name deserves mention here as having devoted his energies, about the same time with Mr Airy, to intricate and laborious researches connected with the least inviting parts of physical astronomy, and striven to redeem England from the reproach of indifference or incapacity in respect of such inquiries. The chief object of his numerous memoirs (in the Philosophical Transactions for 1830, and following years) is to express, in a more convenient and exact manner than had been in use, the complicated serieses indicative of the perturbations as well in the Lunar as in the Planetary Theory.

(118.) MM. Plana and Hansen on the Lunar Theory.

The Lunar Theory: MM. Plana and Hansen.—M. Plana, an astronomer and analyst of the greatest merit, who fortunately still does honour to the native city of Lagrange (Turin), though the author of a great number of Memoirs in the Transactions of the Turin Academy, on different points of Applied Mathematics, is, and will be, best known by his elaborate and learned treatise on the Theory of the Moon. This extends to three very bulky quarto volumes, which are, so to speak, one mass of symbols. Nothing can give a more impressive idea of the condition at which Physical Astronomy has now arrived, than a glance at this mountain of intellectual labour,—especially as to the intricacy, inexpressible by words, of the motions of our own satellite. Here we have a work, not much smaller in appearance than the whole *Mécanique Céleste*, devoted to this one object. It is not superfluous to add, that this is no chimerical undertaking—no curious puzzle—no learned trifling; the Lunar Theory is the grand basis of the Art of Navigation. The real and main use to mankind of our companion planet is a discovery of these latter ages: her cheerful and beneficial light, which all appreciate, and all enjoy, may almost be termed a secondary boon.

(119.) Great work of the former.

The merit of M. Plana is not so much that of an original geometer, outstripping the theories of Laplace and Lagrange, as of a most intrepid and skilful calculator, who has contrived to place in complete order the whole mathematical and many of the arithmetical steps of the solution of one vast problem, extending to some 2000 quarto pages. The calculations he has made unaided! The details are arranged in so lucid a manner, as to court enquiry from those interested in verifying them; and though the readers of so abstruse and indeed repulsive a work must be few indeed, it has already proved of essential service in the way which was intended—the improvement of the lunar tables. The approximations by series are in all cases carried to the fifth powers of small quantities, and, in some instances, to the seventh powers. Sir John Herschel has expressed in forcible and picturesque language the nature of what is wanting to the completeness of Laplace's investigations and which M. Plana has supplied, as regards the theory of the moon's motions:—"In the *Mécanique Céleste*, we admire the elegance displayed in the alternate interlinking and development of formulæ, and exult in the power of the analytical methods used; but when we come to the statement of numerical results, we quail before the vast task of filling in those distant steps; and while cloud rolls after cloud in majesty and darkness, we feel our dependence on the conclusions attained to partake of superstitious trust, or of amicable confidence, rather than of clear and demonstrative conviction."[1] The courage of M. Plana did not "quail" before the serried ranks of symbolic legions. He attacked them first, and finally became their commander. But more than this; on the same high authority, "his analysis is always graceful, his combinations well considered, and his conceptions of the ultimate results to be expected from them perfectly just, and justified by the results when obtained."

Lunar Tables from Theory alone. Carlini—Damoiseau.

I may here mention that M. Plana, in conjunction with M. Carlini of Milan, undertook the calculation of the moon's motions from theory alone (that is, with only the fundamental constants required to be given by observation), in compliance with a programme issued by the French Academy of Sciences on the proposition of Laplace; and that a French geometer, M. Damoiseau, on the same occasion, produced an independent investigation with very elaborate and valuable tables founded thereon.

(121.) M. Plana is the author of many other more circumscribed researches on important points in physical astronomy, in geodesy, and in mathematical physics.

(122.) M. Hansen.

M. **HANSEN**, a German astronomer and analyst of great merit, has made the most recent considerable improvement in the theory of the moon. We will first, however, allude to an invention which is applicable to the whole theory of perturbation.

(123.) General method of perturbations.

We have seen, in the first section of this chapter, that the effects of perturbation may be considered either as applicable directly to the three co-ordinates of the perturbed body, or to the variation of the elements of the orbit considered as instantaneously varying; that the former method has the advantage of being in most cases, and especially in first approximations, most direct; the latter is most applicable to secular inequalities, and has a great recommendation in the exact physical conceptions on which it is founded. M. Hansen has proposed a third method, a refinement, in fact, on that of Lagrange, in which, by an assumption purely mathematical and arbitrary, he throws the effect of perturbation entirely on the element of *time*, so that with the time so altered, and invariable elliptic elements, the conditions of perturbation may be satisfied, and the true place of the body may result from the calculation. Such is the general nature of the conception, which, to be carried out, requires the introduction of subsidiary terms, which serve to correct the latitude and radius vector. The advantages which are understood to follow from this highly artificial mode of proceeding are stated to be (1.) that the serieses expressing the perturbation of the co-ordinates are more convergent than in the other methods, and likewise the coefficients of the terms to be retained are more easily calculated; (2.) M. Hansen considers that his method enables him to ascertain with certainty those terms which, when fully calculated, will affect the result in a sensible manner. The inventor has applied his methods both to the Lunar and to the Planetary theory.

(124.) Two new Lunar inequalities.

We have said that physical astronomy is indebted to M. Hansen for a notable improvement in the theory of the Moon,—the discovery, in fact, of *two* inequalities of long period, the existence of which had been more than suspected from observation, but which were not accounted for. In the infancy of the lunar theory, Euler had predicted that it would always be impossible, on account of the perturbing forces of the planets, to predict the Moon's place within 30″; and it was a quantity of about this measure which remained outstanding after all the resources of analysis seemed exhausted. M. Poisson and Sir J. Lubbock showed that the anomaly could not be due to the solar action, nor yet to the irregularity of the Earth's figure. The planetary attractions, then, alone remained. M. Hansen discovered two independent inequalities due to the action of Venus. One of these is an indirect (or, as it is sometimes called, *reflected*) effect depending on the change of form of the Earth's orbit by the attraction of Venus, which, of course, modifies slightly the solar perturbation of the Moon's longitude. It is, in fact, a secondary consequence of long inequality of Venus and the Earth investigated by Mr Airy [Art. (115)], and has the same period, namely, about 240 years. Its greatest amount is 23″·2. The other inequality discovered by Hansen is of a still more curious and complicated kind, which goes on increasing for 2000 lunations, when it attains a maximum value of 27″·4 in longitude (although the perturbation of the radius vector does not exceed 10 *feet*), after which it diminishes for an equal space of time.

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[1] *Astronomical Society's Monthly Notices*, vol. v., p. 37. The last expressions may astonish some persons, but experienced analytical calculators agree in the same view. Mr Airy (probably the most competent authority in Britain) states the same thing in many passages of his writings, to the effect that the evidence for conclusions so obtained is rather that of *moral* than of *mathematical* certainty.

(125.) His other works.

By these discoveries, the movements of our refractory satellite may be considered to be, after an unprecedented amount of labour, accounted for by theory almost or quite within the limits of the present accuracy of observation.[1] M. Hansen has recently been engaged in perfecting the practical details of the lunar theory, in accordance with the extensive reductions of the Greenwich observations which will be mentioned in the next chapter. He has also given the first complete theory of "Foucault's pendulum," also to be mentioned hereafter. Altogether, he stands amongst the most eminent analytical astronomers of the present day.

(126.) General progress of Physical Astronomy

in Europe,

and in America.

Bowditch.

We have in this section selected (though not by design) representatives of the four great intellectual communities of Europe, engaged in the mighty task of perfecting the theories of physical astronomy. Poisson for France, Airy for England, Plana for Italy, Hansen for Germany. It would be easy, of course, to add the names of many others engaged in similar works, and scarcely less deserving of notice. Some of these will find a place in other chapters, and we have yet one section of this chapter to devote to the history of a discovery of rare interest, in which France and England have a joint share. We may be allowed to mention the names of M. Damoiseau and M. Pontecoulant in France; the former known by his excellent lunar tables deduced from theory, the latter for his calculations of cometary perturbation, and his compendious treatise on physical astronomy, based on the *Mécanique Céleste;* in Italy, MM. Carlini and Santini. But in Germany these studies have been perhaps most systematically pursued. MM. Gauss and Encke have only not been included in this section because we find it more suitable to our plan to associate the name of the former with his theory of Terrestrial Magnetism, and the latter with the recent history of Comets. Bessel likewise was a physical as well as first-rate practical astronomer. I will here only add that these severe and arduous studies have at length been effectually cultivated beyond the limits of Europe. Mr Bowditch (born 1773, died 1838), a private gentleman of the United States, undertook the gigantic labour of translating and illustrating, with a complete commentary in which every difficulty is considered, and every step of analysis supplied, the *Mécanique Céleste* of Laplace. Since his death, a younger race of American mathematicians has taken up the great problems of physical astronomy, amongst whom may be mentioned Mr Walker and Mr Peirce. The latter gentleman has recently (1853) published lunar tables, embracing the latest researches of theory.

§ 5. M. Leverrier—Mr Adams.—*The inverse method of Perturbations. Prediction of the place and orbit of Neptune from the motions of Uranus.*

(127.) The discovery of Neptune from theory by MM. Leverrier and Adams.

We have now to chronicle a discovery which, by general consent, stands first in the achievements of science, not only in the period now under review, but even in the long and eventful series of years which have elapsed since Newton established the doctrine of universal gravitation.

(128.) Its circumstances.

The discovery of which we speak was no less than the proof of the existence of a planet beyond the recognised boundary of our system, merely as an inference from the perturbed motion of the outmost planet Uranus; a proof, not general or abstract, but particular and specific: "Look, on such a night, and in such a direction, and there you will see (by the telescope) a star, small indeed, but with a distinguishable disk,—*that* is the planet which has made Uranus move so unsteadily in its orbit;"—so spoke the mathematician; and the zealous astronomer, to whom the call was especially addressed, pointing his glass to the sky, discovered at once, that is, the same evening, a body answering *almost precisely* in position, as well as in brilliancy, to the oracular announcement.

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[1] M. Hansen has also discovered the course of a small inequality of the Moon's latitude, detected from observation by Mr Airy. His theory of the Moon's figure has been referred to in a note to Art. (57.)

(129.) Its great difficulty.

Since the publication of the *Principia*, or rather we should say since the great theory contained in that work had fully attracted the sympathies of thoughtful and able men, nearly the whole science of physical astronomy consisted in the solution of one vast and intricate problem, which has been called the "Problem of the Three Bodies." To this were bent the powers of Clairaut, Euler, Lagrange, Laplace, Plana, Hansen, and so many more. "Let three bodies be placed and move in a given manner in space and attract one another by the Newtonian law, to determine the motions as affected by their mutual influence." The problem solved independently by the two analysts whose names stand at the head of this section is this, "Given two bodies (the Sun and Uranus) and their relative motion, to find at any moment the position of a third body whose attraction shall be required to account for those motions." To have solved this new and far more difficult problem (under certain limitations) is a triumph altogether unlike in kind to any of the other brilliant successes of which we have had to speak in the preceding pages.

(130.) The great intricacy of the problem is not perhaps at the first moment fully apparent. The perturbation of the known planet (Uranus) is not the effect, either in direction or in amount, of the attraction of the body sought, either at the instant, or at any previous instant. It is an *accumulated* effect arising from the totality of the mutual influences of the two planets during a long space of time, and under a variety of circumstances, which circumstances it is the aim of the solution to discover. But, more than this, we do not even know the quantity or direction of the perturbative action at any moment for which the cause is sought, *for we do not know the purely elliptic elements of Uranus.* His motion has, by hypothesis, been always troubled by this exterior planet, and Uranus has been so short a time known and observed (only accurately since 1781) that the motion has not yet been cleared of ordinary inequalities (due to the action of the unseen body), which, therefore, are inextricably mixed up with the elliptic elements. It is absolutely necessary, therefore, to suppose not only the elements of the new planet to be unknown, but also the elements of Uranus to be severally affected by unknown errors. This nearly doubles the unknown quantities to be found.

(131.) History.

We shall now glance at the history of these unexplained perturbations, and at the rise and growth of the idea of their being explicable by the influence of an unseen body.

Irregularities of the motions of Uranus.

(132.) After Sir William Herschel had discovered, in 1781, the planet which he called Georgium Sidus, (afterwards named Herschel, and finally, by general consent, Uranus,) it was easy, by a few observations, to ascertain its approximate orbit and distance from the sun. But the extreme slowness of its motion (it will not have completed a single revolution before 1861) made it impossible to determine its elements with precision, until it had been discovered that the records of astronomy contained about twenty observations of this body before its planetary nature was discovered; being, in fact, registered places of fixed stars where no stars exist, concurring in brightness and position with the circumstances of Uranus at those remoter periods; the earliest of these observations was one of Flamsteed, in 1690. The first person who constructed tables of the planet was Delambre; but even at that early period, it was remarked, that the modern were not satisfactorily reconcilable with the ancient observations; and, finally, Delambre included of the latter only one, by Mayer, which he did, he tells us, "out of pure respect," although it certainly rendered the tables less exact and less durable. The longer the planet was observed, and the greater the care that was expended in analysing and combining the observations, the more clearly it appeared that the tables had only an *empirical* character, satisfying observations for a few years before and after the time for which they had been constructed; and that, in particular, as the nineteenth century advanced, the deviations from elliptic regularity became more and more intolerable, till the "ancient" observations were at length totally given up. This was the state of matters in 1821, after M. Bouvard of the Observatory of Paris, a most able calculator, had exhausted every resource in improving the Tables of Uranus. A few years more gave that patient astronomer the mortification of seeing his tables as obsolete as those of his predecessors, and numerous surmises were circulated as to possible explanations of the anomaly: a failure in the law of gravity, cometary perturbation, a resisting medium, and, finally, the presence of an unseen planet, were amongst these guesses. The last and most plausible of these hypotheses occurred to many; amongst others, to Mr Hussey in England, M. Bouvard in France, and later to M. Bessel in Germany.[1] The first of these astronomers actually consulted Mr Airy, in 1834, on the possibility of predicting the place of the perturbing planet from theory, and then discovering it by observation. Mrs Somerville, in 1836, gave a precise expression to the same idea.[2] From this time the subject could not be lost sight of. The errors of the tables which in 1821 were insensible, increased in 1830 to 15″ or 20″, and in 1845

Hypotheses to account for them.

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[1] Clairaut, nearly a century before, in calculating the return of Halley's comet, hinted at the possible perturbation due to a planet superior to Saturn.

[2] In her *Connection of the Physical Sciences.*

amounted to *two minutes* of longitude. M. Bouvard to his latest years, perhaps his latest hours,[1] cherished the hope of extricating this theory from its difficulties. He also engaged his nephew M. Eugène Bouvard in the same career, who appears to have followed it with much zeal and intelligence, and in 1845 constructed new tables of Uranus. But by this time two geometers had separately and independently undertaken the problem, with the determination of finding, if possible, a physical solution of all this perplexity. The earliest in point of date was Mr Adams, a young graduate of Cambridge; the other was M. Leverrier of Paris, whose attention was directed to the subject by M. Arago. As the researches of M. Leverrier, though second in point of time, occasioned the actual recognition of the planet, and thus stamped the correctness of the solution with success, we shall consider them in the first instance.

(133.) M. Leverrier's investigations; M. Leverrier is, we believe, a native of St Lo in Normandy, a province which has been singularly productive of eminent men (Laplace and Fresnel were of the number). With no advantages, but the reverse, he won a high position at entering the polytechnic school, which he constantly maintained. He at first, we believe, attached himself to chemistry, but his taste for physical astronomy was soon developed, and was advanced entirely by his private efforts. It is a peculiarity of the mode of cultivating the sciences in Paris, that such abstruse and difficult studies are not merely engaged in temporarily for purposes of academial distinction, but that they actually become a "carrière" or *calling*, and are pursued in that methodical manner for which the French are distinguished. In 1845, when he commenced the careful examination of the theory of Uranus, M. Leverrier was already favourably known by his researches on comets, and on the orbit of Mercury, but especially by immense calculations, connected with the secular inequalities of the planets, by which his ability and hardihood in computation had been thoroughly exercised. He began his new enquiry with the method and intrepidity of calculation which distinguish him. He revised with the most minute care the observations of Uranus, and computed afresh every sensible perturbation which theory recognised as arising from known planets. This done, and having compared the most probable orbit with observations which he collected from authentic sources, and especially from the Greenwich observations which were communicated to him for this purpose, the result was, that even confining himself to observations since 1781, arranged in eleven convenient groups (each resulting from many observed places), and attributing to each group the largest error which could be in reason allowed, and even admitting that all these errors were in the direction most favourable to the assumption, it was still impossible to account for more than one-fourth part of the observed discordances.

(134.) M. Leverrier then assumed that a perturbing planet existed beyond the orbit of Uranus, and at nearly double its distance from the sun, in conformity with the empirical law, (usually attributed to Bode the German astronomer,) which expresses with general accuracy, thus far, the arrangement of the planetary system. The law is, that the distances of the planetary orbits from Mercury are successively doubled. This assumption—(it was absolutely necessary to assume some distance to begin with)—was ingeniously confirmed by other considerations.

(135.) how conducted: Leaving the perturbations *in latitude* out of account, he now considered each error of Uranus in longitude as the expression of a perturbation due to the action of the unknown planet, and capable therefore of algebraic expression in terms of the elements of that planet, namely its excentricity, longitude of perihelion, epoch in its orbit, and mass; but, as we have already remarked, the first three of these elements must be considered as incorrectly assumed for Uranus itself, as well as the mean distance of that planet, and, therefore, there are four unknown corrections for its elliptic elements, making in all eight quantities to be eliminated from the discordances of theory and observation. So complex an elimination cannot be directly effected; and even if it could, the result could not be depended on, as the possible error of each observation involves a fresh and important source of doubt in the conclusion. M. Leverrier proceeded, by a series of gradually restricted assumptions, to find within what limits the more important elements might be made to vary without producing effects incompatible with observation, and his attention was at first confined to the approximate mean longitude of the planet. He obtained a result after a prodigious amount of tentative calculation. The excentricity and position of the perihelion were then inferred. On the 1st June 1846 he announced to the Academy of Sciences that the true longitude of the expected planet for 1st January 1847 was 325°, with a probable error of 10°. This result was immediately published in the *Comptes Rendus*. Their result.

(136. M. Leverrier's final announcement; Between the 1st June and 31st August 1846, when his third memoir on the perturbations of Uranus appeared, M. Leverrier busied himself in obtaining a farther approximation to the elements and place of the suspected planet. He now assumed the correction of the mean distance amongst the other quantities to be sought. By a fresh calculation he

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[1] M. Bouvard was born in 1767. He performed almost all of the numerical calculations required by Laplace in his great work, and was associated with that eminent man by the most friendly ties. He "ceased to calculate and to live" 7th June 1843.

deduced a complete list of elements as regards longitude; and diminished the mean distance considerably. The true longitude by this calculation differed only $1\frac{1}{2}°$ from his previous estimation. He finds for the mean distance from the Sun 36 times that of our Earth (that of Uranus being 19), the period 217 years, and the mass $\frac{1}{9300}$ of the Sun's. Assuming the density of the planet to be the same as that of Uranus, he conjectures that the apparent diameter will be 3″·3; that it will therefore have a visible disk sufficient to distinguish it from a fixed star, and that its brilliancy should equal that of a star of the 8th or 9th magnitude. As the result of these suppositions, he found that the whole errors in the places of Uranus from 1781 to 1844 were reconciled within quantities amounting but in one instance to 5″; that the ancient observations of the 18th century were reconciled within 7″ or 8″; and the oldest observation of all, that of Flamsteed in 1690, had an outstanding error of 20″, a quantity very far from excessive, considering the state of astronomy at that period.

(137.) resulting in the discovery of Neptune by M. Galle.

No one who read at the time the abstract of this remarkable paper in the *Comptes Rendus* failed to be struck with it, not only as regarded the weighty matter, thus publicly announced, but also on account of the calm and well-grounded conviction which the author manifested in the truth of his bold conclusions, and the definite manner in which he gives the challenge to practical astronomers to verify or disprove them. "Since Copernicus declared" (according to the prevalent tradition) "that when means should be discovered for improving the vision, it would be found that Venus had phases like the moon, nothing," writes Mr Airy, "so bold, and so justifiably bold, has been uttered in astronomical prediction." M. Leverrier had hastened his calculations in anticipation of the approaching opposition of the new planet in the autumn of 1846, but it is very doubtful whether astronomers would have made the discovery at that time, but for his personal application to M. Galle, then assistant-astronomer at Berlin, where a powerful refractor suitable for the search existed. So ardent a conviction in a manner compelled the proof which the geometer claimed, and M. Galle, whose intelligence and zeal are well known, pointed his telescope to the sky the very evening that M. Leverrier's letter reached him. Fortunately provided with a newly published star map by Brenicker of that region of the heavens, which was not at that time diffused generally amongst European observatories, he detected that same night (the 23d September 1846) a star-like body of the 8th magnitude, *not* noted in the star chart, therefore a wandering body, having a manifest disk from $2\frac{1}{2}''$ to 3″ in diameter, and distant only *fifty-four minutes of a degree* from the predicted place.

(138.) It will be remarked that the discovery in question was anticipated and completed in France and Germany alone; England had no direct participation. We must now, however, state briefly what occurred there of a similar character at the same time, and even earlier.

Mr John Couch Adams, when a student at St John's College, Cambridge, in 1841, formed the design of detecting the position of a perturbing planet which should account for the anomalous motions of Uranus. He made a preliminary essay on the problem in 1843, assuming the distance of the suspected body from the Sun to be double that of Uranus. I learn from good authority that he obtained a place for the unseen planet not very different from that which he finally adopted. Early in 1844 he obtained from Greenwich the valuable series of places of Uranus which were afterwards in like manner applied for by M. Leverrier. In September 1845, he communicated to Professor Challis the elements of the new planet's orbit (neglecting the inclination) and an ephemeris of its geocentric place; and in October he transmitted the elements also to the Astronomer Royal. This, it will be observed, was soon after M. Leverrier's attention was first directed to the subject, and nine months previous to his announcement of the locality where the new body should be sought. Mr Adams afterwards repeated his calculation with a mean distance $\frac{1}{30}$th less than before, and considered himself warranted, by the improvement thus produced on the residual errors, in inferring that a farther considerable diminution of the mean distance would satisfy the observations still better. This was communicated to Mr Airy on the 2d September 1846; subsequently therefore to the publication of M. Leverrier's Elements. Mr Adams, in communicating his results (at a later time) to the Astronomical Society, with characteristic modesty says, "I mention these dates merely to show that my results were arrived at independently, and previously to the publication of M. Leverrier, and not with the intention of interfering with his just claims to the honors of the discovery, for there is no doubt that his researches were first published to the world and led to the actual discovery of the planet by Dr Galle." (139.)

Mr Adams preceded M. Leverrier in a similar investigation;

(140.) but the planet was not discovered in consequence.

And such is no doubt the fact. The priority of Mr Adams in the mathematical investigation is as certain as that the researches of M. Leverrier alone produced the discovery of Neptune. Even the search for the planet which took place in August and September 1846 at Cambridge by Professor Challis, was not occasioned by Mr Adams' researches only; it was the near coincidence of the longitude assigned by Mr Adams in the previous October with that published by M. Leverrier in June 1846 which induced Mr Airy to suggest this investigation of the heavens, and to offer (if need were) himself to bear the expense. Had the planet been discovered[1] at Cambridge before it was at Berlin, M. Leverrier must still have had a share in the credit of success.

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[1] The planet was indeed *seen* at Cambridge by Mr Challis, for it was recorded more than once amongst the numerous fixed stars whose places were taken down in the progress of the search; but as the comparisons of the "sweeps" were not made at the time, the discovery was anticipated by M. Galle.

(141.) Remarks on the history. It is perhaps to be regretted that Mr Adams had not given his whole investigation to the world, or at least published his results, so as to avouch the confidence which he felt in his own prediction, and to throw upon practical astronomers generally the responsibility of its verification. Had he done so in 1845, it is *possible* that the planet might have been discovered at the opposition of that year; but it is at least certain that M. Leverrier's claims to priority as regards the discovery of Neptune would have been effectually anticipated. But it is only just to our countryman to recollect the difference of his age and position. M. Leverrier was at the time about 35 years of age, and was a candidate for the substantial benefits as well as for the honour of a membership of the Academy of Sciences. Mr Adams must have been nine or ten years younger at the period of this discovery, a circumstance which enhances our admiraion at the achievement, whilst it gives an additional grace to the modest conduct of the author.

(142.) I have endeavoured to state correctly (with due regard to the limits of this essay) the main facts of the most curious case of double discovery which, perhaps, the history of science presents; and happily as to the facts, down to the minutest detail, no discrepancy of opinion ever existed. Different minds will, with perfect truth, attach more or less distinction to the two illustrious rivals,—neither of whom has for an instant lowered the dignity of his position by one ungenerous expression,—but that the absolute merit of both is of the very highest character is on all hands admitted. "The names of M. Leverrier and Mr Adams," said Sir John Herschel, addressing the Astronomical Society, "which Genius and Destiny have joined, I shall by no means put asunder; nor will they ever be pronounced apart so long as language shall celebrate the triumphs of Science in her sublimest walks."

(143.) Old observation of Neptune as a fixed star. But before closing, I must briefly state how far the orbit of the planet Neptune, when discovered, realized the previsions of theory. A fortunate circumstance rendered it easy to obtain at an early period a correct knowledge of the elements. It seems that the planet Neptune was observed by Lalande at Paris on the 8th and 10th May 1795, and entered as a fixed star, *notwithstanding a distinct change of place between the observations*, actually corresponding to what the planet should have had.[1] But such an oversight had been made by Lemonnier in the case of Uranus. By means of this observation of fifty years back, the orbit was easily computed. It is a singular and startling fact, that, except as regards the longitude on the orbit, the other elements computed from observation were somewhat widely different from those assigned by M. Leverrier and Mr Adams. We shall present them in a tabular view. The value of the mass in the last column is calculated from the elongation and period of a satellite of Neptune discovered by Mr Lassell.

	Theory—Leverrier.	*Theory—Adams.*	*Observation—Walker.*
Epoch of Elements, . .	1st Jan. 1847,	6th Oct. 1846,	1st Jan. 1847.
Mean Longitude, . .	318° 47′	323° 2′	328° 33′
Mean Distance, . . .	36·15	37·24[2]	30·04
Period, ...	217·4 years		164·6
Long. Perihelion, . .	284° 45′	299° 11′	47° 12′
Excentricity, . . .	0·1076	0·1206	0·00872
Mass, ...	$\frac{1}{9300}$ of Sun's	$\frac{1}{6700}$	$\frac{1}{19800}$[3]

(144.) The differences of theory and observation are so striking as to have occasioned surprise to many persons that, with data so erroneous, the perturbations of Uranus or the longitude of Neptune at the epoch of discovery should have been obtained even approximately.

(145.) How an assumption of erroneous elements led to the discovery; The fact, however, is this:—that the mutual perturbations of Uranus and Neptune are sensible for only a small portion of the joint orbits when the planets are nearly in conjunction. The conjunction (when the mutual distance is least and the attraction strongest) took place in 1822. Now the places of Uranus from 1690 (the first observation) until 1800 can be sufficiently well represented by elliptic elements. The perturbation of Neptune became sensible therefore only twenty years before conjunction. In this time Neptune describes (really) only $\frac{1}{8}$ of a circumference, or 45°, and *relatively to the motion of Uranus* about the same. It is evident then that even a considerable error in the period of Neptune would scarcely sensibly affect the law of perturbation during twenty years, and that the approximate determination of the place of the perturbing planet about the time of conjunction will not be much affected by the error of that assumption. Again, as to the error of mean distance, we may observe, that since the mutual action of the planets is confined within such (comparatively) narrow limits of space and time, though we might anticipate a tolerable approximation to the interval between the bodies

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[1] One of the observations was suppressed in the publication, and only discovered on searching Lalande's MS.

[2] This was the hypothesis upon which Mr Adams made his second or corrected calculation of clements. Nevertheless, he inferred from that calculation that the mean distance might with much probability be reduced to 33·4.

[3] Pierce. Struve's mass is $\frac{1}{14600}$.

at that time, it would be unreasonable to expect a correct determination of the form and ellipticity of the orbit of Neptune, such as might be looked for if the perturbations were sensible through the entire orbits; and in fact, by varying the position of the perihelion and the amount of excentricity, we may, for an *assumed* mean distance, obtain any value whatever for the interval of the two planets at a particular time. We have seen the origin of the false assumption of mean distance on the part both of M. Leverrier and Mr Adams, and we find that the mathematical solution corrects to a great extent the error of that assumption by giving a correspondingly incorrect position of the perihelion, and also an exaggerated measure of the excentricity, by which two circumstances the planets of both mathematicians would have had, near the time of conjunction, a distance from the sun of only 32 or 33 radii of the earth's orbit, the true distance being about $\frac{1}{12}$ part less. This still remaining error was palliated, and evidently might for a time have been completely masked, by assuming a mass of Neptune proportionally too great, as indeed the table we have given shows was the case.

(146.) and why the discovery took place when it did. That the discovery of Neptune took place at the time when it did was no accident. The conjunction of Uranus and Neptune, when alone the perturbation of the elliptic elements is perceptible, is a rare phenomenon, occurring but once in about 172 years. The last conjunction previous to 1822 was in 1649: we have seen that the attention of astronomers was importunately called to the subject by the irregularities in the motions of Uranus at the first conjunction succeeding its discovery.

(147.) Principal inequality of Uranus and Neptune. We are indebted to Professor Peirce and Mr Walker of the United States for many useful investigations connected with the orbits of Uranus and Neptune; but it is to be wished that the theory were completely re-examined, and also the problem of the inverse method of perturbations which has now become a systematic portion of physical astronomy. The near commensurability of the two periods presents a peculiar case of perturbation similar to the long inequality of Jupiter and Saturn; but as its period is no less than 4047 years,[1] although the coefficient of the inequality is considerable, it will not perceptibly alter the motions of either planet except in a long course of years.

(148.) Other works of MM. Adams and Leverrier. It will not be supposed that either M. Leverrier or Mr Adams could, after such a memorable triumph, abandon the pursuits of physical astronomy. The first has continued his researches on the orbits of comets and on the perturbations of the solar system; and having been recently appointed to succeed M. Arago in the direction of the Paris Observatory, we cannot doubt that he will infuse new life into its management. Mr Adams has made the discovery of some important oversights in the details of the lunar theory. One of these, with reference to Laplace's Theory of the Secular Acceleration of the Moon's mean Motion, has been referred to in a note to Art. (62). Though Mr Adams occupies no public post, and though he has declined the honours of a title, his continued residence at Cambridge must influence very beneficially the studies of the place, where some of his many friends have founded in memory of his achievements a perpetual prize for the advancement of physical astronomy, which is denominated the Adams Prize.[2]

CHAPTER III.

ASTRONOMY.

§ 1 Maskelyne—Delambre.—*Progress of Practical Astronomy from* 1770 *till* 1810—*Of the Lunar Theory deduced from Observation—The Density and Figure of the Globe.* Cavendish; Baily. *Trigonometrical Surveys.*

(149.) Practical Astronomy 1770–1810. As examples of those astronomers who most contributed in the period of which we now principally speak (1770–1810) to the progress of *exact* observation, whether of the motions of the heavenly bodies or of the figure and density of our own planet, I have selected Maskelyne and Delambre. Their characters were both distinguished by modesty, simplicity, and love of truth. Of all their contemporaries of eminence, few escaped so happily from the unprofitable strife of rivalry and personal disputes, and none exhibited a more impartial desire for the advancement of the science to which they were devotedly attached. Perhaps neither was a man of lofty talent, yet they did not fail to secure deserved respect in their own day, and far more gratitude from the posterity whom they essentially benefited than falls commonly to the share of men of higher pretensions in this respect. Both their names are important links in the history of astronomy.

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[1] According to the calculations of M. Peirson (*Camb. Trans.* vol. ix.).

[2] It has been our business to condense the history of the discovery of Neptune within a compass proportioned to the general scheme of this Dissertation. The reader who desires farther details will consult M. Leverrier's Memoir on the Perturbations of the Herschel planet (Uranus) in the *Connaissance des Temps* for 1849 (also published separately), and in the *Comptes Rendus* for 1846; Mr Adams' papers in the *Nautical Almanac* for 1851, and the *Astronomical Society's Memoirs*, vol. xvi.; Mr Airy's singularly curious and impartial Historical Account in the 7th vol. of the *Astronomical Society's Monthly Notices*; M. von Lindenau's History in Schumacher's *Nachrichten* (Ergänzungsheft) (favourable to M. Leverrier); Grant's *History of Physical Astronomy* (advocating principally the claims of Mr Adams). Sir J. Herschel's *Outlines of Astronomy* contain a very valuable description of the scientific part of the question.

(150.) Maskelyne; NEVIL MASKELYNE, born in 1732, and educated at Cambridge, was early attached to astronomical pursuits. After various minor services connected chiefly with navigation and the discovery of the longitude, he attained the honourable post of Astronomer Royal, which he filled from 1765 till 1811 with distinguished success. His immediate predecessor was Dr Bliss, who held the office for but three years and without distinction. Practically, Maskelyne may be said to have succeeded Bradley, probably the greatest astronomer whom England has yet seen, whose discoveries have been recorded in the last Dissertation, and whose observations, through a variety of circumstances, were destined rather for the benefit of the nineteenth century than for his own. Maskelyne wisely recollected that the observatory was mainly founded for the improvement of navigation,[1] and one of his earliest labours was the establishment in 1767 of the "Nautical Almanac," a work based on the best astronomical observations and of the highest service to seamen. "During Maskelyne's long tenure of office he was entirely devoted to its duties, making himself all the most delicate observations, particularly those of the moon, and rarely quitting the observatory except to attend the meetings of the Royal Society. The perfect method and continuity of his observations give to them a great value, especially for the correction of the Lunar Tables, in which respect they are indeed without a parallel. But the regularity of their publication was not their least merit. Four large folio volumes include the patient labours of a life (for he had but one assistant). Delambre in his character of Maskelyne says, that if through some catastrophe the whole materials of science should be lost, except these volumes, they would suffice to reconstruct entirely the edifice of modern astronomy."[2]

value of his observations at Greenwich. In fact, on Maskelyne's accession, the only methodical publication which had issued from Greenwich Observatory was the "Historia Celestis" of Flamsteed; Halley's, Bradley's, and Bliss's observations remained in manuscript. A like fate attended most of the foreign astronomical observations; labours the most irksome and conscientious lie buried in piles of MS. useless to science, and which therefore might almost as well have never been made. This is particularly the case with the Parisian observations (as the impartial Delambre records with pain), commenced even before the time of Flamsteed; but which, owing to this cause principally, have remained even to the present day (and it is *forty years* since Delambre wrote his patriotic protest) without contributing materially to advance astronomy. Let it then be recorded to the honour of Maskelyne, that this important step of regular and full publication at the public expense was entirely due to him. His places of the sun, moon, and planets, were the foundation of the improved theories of physical astronomy, then more ably cultivated on the Continent than in Britain, and of the tables also chiefly furnished by German and French computers.

(151.) Maskelyne's more important contributions to science may be briefly stated under these two heads;—The determination of the Lunar orbit from observation, and its application to navigation; and the determination of the local attraction of Schehallien and of the density of the earth.

(152.) Lunar observations. I. *The determination of the Lunar Orbit from Observation and its application to Navigation.*—Though astronomy owes (as we have already said) much to Maskelyne in the exact determination of the places of the sun, planets, and the most conspicuous fixed stars, the comparison of the Lunar place with the tables was by far the most arduous and the most important of his undertakings. It was the most arduous, because, from the extreme complexity of the moon's motions, every part of its orbit must be narrowly watched, requiring the astronomer's presence at his instruments at all possible hours during the course of a lunation, these motions being subject to important changes which recur every nineteen years, besides others of yet far longer duration. It was Maskelyne's good fortune, and at the same time the reward of his perseverance, to watch three revolutions of the lunar nodes. He did not content himself, however, with *making* observations; he contributed in every possible way to the improvement of the tables of the moon's motion. He was in constant communication with Mayer, one of the ablest astronomers of his day, and he directed the calculation of Bradley's observations by Mason, for the farther improvement of Mayer's Tables. Maskelyne's own observations, to the number of at least 5000, were used by Bürg in his excellent tables of the moon which have even yet been hardly surpassed; but their full value has only been tested recently by the systematic reduction of all the lunar observations of Maskelyne and Pond, and a comparison with Damoiseau's tables, under the direction of the present Astronomer Royal, Mr Airy.

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[1] In the warrant appointing Flamsteed to be the Royal "Astronomical Observator," his duty is declared to be "to rectify the tables of the motions of the heavens and the fixed stars, so as to find out the so much desired longitude at sea, for perfecting the art of navigation."

[2] From an article on Greenwich Observatory in the *Edinburgh Review*, written by the author of this Dissertation.

(153.) The *Nautical Almanac.* But, for the application of the method of lunar distances to navigation, farther aid than the construction of good tables was required. This Maskelyne provided by obtaining the regular publication of the Nautical Almanac, superintended by himself, and containing the distances of the moon from the principal fixed stars at predetermined hours for the meridian of Greenwich, a comparison of which with the distance observed by means of the sextant in any part of the world enabled the seaman (after proper reductions) to infer the exact *Greenwich* time of the observation, and thence, by comparison with the *local* time obtained by the usual methods, to obtain his longitude. To this, long admitted to be the best practical solution of the celebrated problem of "the longitude at sea," Maskelyne contributed probably more than any other person. His "Lunar Distances" were reprinted in the French Almanac (*Connaissance des Tems*) for a considerable number of years.

(154.) Attraction of mountains. II. *The determination of the Attraction of Schehallien, and of the Earth's Density.*—The deviation of the plumb-line from the vertical by the neighbourhood of a mountain had been pointed out by Newton[1] as a direct consequence, and also as a test, of the principle that gravity resides in every part of the earth as well as in the earth as a whole. Bouguer had the merit of pointing out the form in which the experiment might be made, and of making the trial, though in a rude and insufficient manner, in the Peruvian Andes in 1738. He observed the effect of the mountain on the south side only, but at two stations unequally distant from its centre of attraction. The numerical result being (as the author himself admitted) without value, Maskelyne proposed to the Royal Society in 1772 to repeat the observation on some British mountain. A "Committee of Attraction" was named, which, besides Maskelyne, included Cavendish, Franklin, and Horsley. Cavendish, as might have been expected, took an earnest part in it. The search for a suitable hill was confided to Mr Charles Mason in 1773. Skiddaw and the Yorkshire Hills were first thought of, but finally Schehallien in Perthshire was preferred.[2] Thither Maskelyne himself proceeded in 1774, with his assistant Burrows, and by these two, with the aid of a local land-surveyor, the labour of the astronomical and chief geodetical operations, including the measurement of two base lines, was effected between the 30th June and the 24th October, notwithstanding the hindrances of a most unfavourable season.

(155.) Maskelyne's observations at Schehallien. The distance between the two stations obtained with Ramsden's 9-inch theodolite, was 4364·4 feet, which in the latitude of Schehallien corresponds to 42″·94 of latitude. The observed difference of latitude by 337 observations with Sisson's 10-feet zenith sector was 54″·6.[3] The excess, or 11″·6, is the double attraction of the hill drawing the plumb-line towards itself at the two stations. The sine of this angle, or $\frac{1}{17804}$, represents the *actual* ratio between the double attraction of the hill and the attraction of the earth. But by the computation of the attraction which the hill ought to exert, from its figure, as determined by Maskelyne's gauges, were its density the same as that of the globe generally, this ratio should amount to $\frac{1}{9933}$, which can only be accounted for by assuming the earth to be denser on the average than the hill of Schehallien in the proportion of 17804 to 9933. This deduction was made by Dr Hutton by means of a troublesome calculation of the summation of the attractive effects of a number of vertical prisms into which the hill was imagined to be divided. The artifices of calculation were, however, due to Cavendish (who it will be recollected was on the "Committee of Attractions,") as Mr Airy ascertained from his manuscripts. Earth's density deduced. A careful lithological survey of the hill enabled Professor Playfair to deduce the probable mean specific gravity of the globe to be between 4·56 and 4·87, which was somewhat greater than Dr Hutton assumed it.

(156.) Michell and Cavendish's experiment for the same end. This is the proper place to mention an experiment on the density of the Earth perhaps still more remarkable, devised by the Rev. Mr Michell, who constructed the apparatus, but first put in practice by Mr Cavendish in 1797–8. It consisted in measuring the force of gravitation between two spheres of such small size that they could be moved by the hand nearer to or farther from one another. The essential part of the invention was to contrive a balance so delicate as to measure the almost inappreciable tendency of such small bodies to unite. Newton had shown that the attraction at the surface of any sphere is directly as its radius, which he observed must always be incomparably smaller than their tendency towards the earth, that is, their weight. In the largest and heaviest masses with which it has hitherto been found practicable to operate, this tendency amounts to only a very minute fraction of a grain. How could such quantities be *accurately* estimated, so as not only to leave no doubt of the phenomenon of gravity thus acting on the small scale, but to deduce its amount, and hence to weigh the globe?

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[1] De Mundi Systemate, § 22. Newton, in a very remarkable passage of the Third Book of the Principia (Prop. X.), conjectures that "the quantity of matter in the earth may be five or six times greater than if the whole were composed of water."

[2] A laughable mistake of Zach in his account of the Schehallien experiment (in his *Attraction des Montagnes*) is commented on by Playfair in the Edinburgh Review. In a note to the word Schehallien, Zach says, "Montagne appelée dans le pays en langue Erse *Maiden pap*, qui veut dire *orage perpetuel.*" It is needless to add that these two alleged *synonyms* are different interpretations given by Gaelic scholars of the word. "From this inaccuracy," adds his reviewer, "his residence in London ought to have delivered him, for though he could not learn there what was Erse, he might have learned what was English."

[3] Zach obtained the same result exactly by including all the observations, as Maskelyne had provisionally obtained by using only those stars on which he most depended.

(157.) The Torsion Balance.

Mitchell imagined for this purpose *the balance of torsion*, which was re-invented by Coulomb (who probably first executed it) for the purpose of measuring electrical forces. Mitchell's apparatus came first into the hands of Wollaston, then of Cavendish, who made the experiment. He used a very light rod of deal, six feet long, suspended by a fine silver or copper wire, forty inches long, within a wooden case to defend it from currents of air. At each end of the lever was hung a ball of lead, two inches in diameter, and by a simple contrivance a pair of leaden spheres, weighing, together, 348 pounds, could be brought simultaneously into the neighbourhood of the balls (but outside the case), on opposite sides, so that their attractions might concur to swing the suspended lever out of the position of repose which it had previously taken up, under the action of the slight twisting force of the silver wire. A new position of rest was thus established, the small balls being pulled as much one way by the attraction of the spheres as they were urged in the opposite direction by the torsion of the wire. The position of repose being observed from a distance by a telescope (to avoid disturbance from the heat of the observer's body), the great spheres were then changed in position so as to act upon the opposite sides of the small balls, from what they formerly did. The deflection and new stable position would be as much on the other side of the zero, and the arc described would be an accurate measure of the double deflection. The force of torsion for 1° of deflection is known by the time of oscillation of the lever and balls when free, and as the forces are exactly as the angles, the force corresponding to any displacement becomes known. Cavendish conducted the experiment with his usual patience, judgment, and success; he found the joint attraction of the small balls and large spheres to be about $\frac{1}{4300}$ of a grain, their centres being 8·85 inches apart, and he thence computed the density of the Earth to be 5·48 times that of water. Cavendish's paper is as usual a model of precision, lucidity, and conciseness. The attraction of the fixed parts of the apparatus is calculated and allowed for.

Result.

(158.) Baily's result.

It would be difficult to mention in the whole range of physics a more beautiful and more important experiment. It has been repeated since by Reich of Freiberg and Baily of London. The former obtained 5·44, the latter 5·66 for the Earth's specific gravity; this last result being worthy of much confidence from the extraordinary care taken to avoid errors and to obtain independent values of the quantities sought.[1]

(159.) Maskelyne's improvements at Greenwich.

Maskelyne continued his zeal for the promotion of astronomy to the last. He superintended the publication of 45 annual volumes of the *Nautical Almanac*. He left the whole of the observatory work in perfect order, and the greater part printed. He had the well-earned satisfaction of finding his observations in request in every civilized country, the bases of the most useful tables, and the tests of the most advanced theories. He cultivated the friendly correspondence of astronomers in every country. Not given to change, he preserved the instruments and chief methods of the immortal Bradley; but sufficiently alive to the necessity of progress in the sciences, he introduced many simple but practical improvements in the art of observation. Even in his last years, satisfied that the celebrated quadrant of Bird was no longer the best instrument for its purpose, and was besides sensibly deteriorated by use, he adopted the circle instead (then recently come into notice, though first used more than a century before by Römer), and directed the construction of that by Troughton, though it was not placed at Greenwich until after his death, which occurred in 1811, in the 79th year of his age. His biographer Delambre mentions, that a considerable number of his posthumous memoirs were put into the hands of Professor Vince for publication. They have not, however, appeared.

(160.) Its superiority to Continental observatories at that time.

Practical astronomy was on the Continent far behind its state in England at the period of which we speak. The various national observatories contributed comparatively little to the progress of science; but there were of course exceptions, a few of which we will here briefly notice.

(161.) Astronomy on the Continent. Olbers—Piazzi.

The discovery of the four small planets[2] Ceres, Pallas, Juno, and Vesta, the first by Piazzi, the second and fourth by Olbers, the third by Harding, gave celebrity to those astronomers, of whom Piazzi and Olbers were farther distinguished by many important labours. To the latter we owe the discovery of several comets, and one of the best methods of calculating their orbits from observation. He was a person of much simplicity of manner, made his observations with the most unpretending means in the attic of his house, and died at a great age generally respected. His firmest friend was Baron von Zach, who had no slight share in the discovery of the new planets, owing to his having instigated the association of twenty-four astronomers, chiefly in Germany, for the express purpose of ascertaining whether no planetary body filled the void between Mars and Jupiter. To Piazzi, of Palermo, we owe a most excellent catalogue of fixed stars from observations with a moveable circle of four feet radius by Ramsden. Oriani of Milan was likewise one of the best informed practical astronomers of his time.

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[1] The experiments of Cavendish are related in the "Philosophical Transactions" for 1798; those of Reich in a separate small work, entitled "Versuche über die mittlere Dichtigkeit der Erde," Freiberg, 1838; those of Baily in the "Memoirs of the Astronomical Society," vol. xiv. A still more recent series of experiments by Reich gives 5·58, a close approximation to Baily's result.—(*Phil. Mag.* March 1853.) From observations with a pendulum in Harton coal-pit in 1854, Mr Airy has obtained a density higher than any of the above.

[2] In the Fifth Dissertation, page 789, Harding instead of Olbers is named as the discoverer of Vesta.

In France, after the death of the celebrated Lacaille, perhaps Lalande (who was exactly Maskelyne's contemporary) was the most active astronomer. To him and his nephew we owe a very valuable catalogue of 50,000 stars, lately edited by the British Association. But practical astronomy was seriously neglected in France generally. The national observatory was feebly superintended by the later members of the Cassini family; of the French expedition under Maupertuis to measure the length of a degree in Lapland, the Abbé Outhier alone, it is said, knew how to use a quadrant, and the celebrated Lagrange was as ill informed until instructed by Lalande.[1]

(163.) French arc of the meridian.

But the most important labours of the French astronomers at the close of the last, and at the commencement of the present century, were in carrying out the measurement of the arc of the meridian from Dunkirk to the Balearic Isles, with the more immediate object of fixing the length of the *mètre*, but contributing to the solution of far more considerable problems connected with the FIGURE OF THE EARTH. We connect this labour with the respectable name of Delambre, who was more intimately associated with it than perhaps any other person, though united with such eminent men as Méchain, Biot, and Arago.

(164.) Delambre; his character and talents.

DELAMBRE was the pupil of Lalande, who used to say that his disciple was his best work. He first obtained distinction as a computer of tables. Those of the motions of the Sun, Jupiter, Saturn, and Uranus, and of the satellites of Jupiter were deservedly prized, and some of them are still the best of their class. He was a man in whom the love of truth and accuracy was conspicuous. Learned and patient, he spared no pains in acquiring knowledge, and in using it to the best purpose. As a calculator he was eminent. Physical astronomy he did not cultivate, except with a view to compare its deductions with facts. He was intimately conversant with all properly astronomical methods and formulæ. He knew the history of every problem, and the details and modifications of every astronomical instrument. He has embodied the results of this vast industry in a series of works (forming six quarto volumes) on the history of his favourite science, which are without a parallel for fulness and impartiality. He laboured as conscientiously to ascribe the due credit to Hipparchus and Ptolemy as to hold an equal scale between the merits of French and British astronomers. His critical knowledge of the ancient languages (for he could speak Greek with fluency) was not more remarkable than his complete freedom from national prejudices. Both attributes qualified him pre-eminently for the office of an historian. He published also a large treatise on astronomy, and numerous memoirs on practical subjects in the *Connaissance des Tems* between 1788 and 1817.

(165.) History of the French Arc.

Of his original labours the measurement of the French Arc of the meridian, of which he has given a full account in his *Base du Systême Mètrique Decimal*, is the most important. As some account of this undertaking has been given in Sir John Leslie's Dissertation, I shall state concisely a few particulars not there mentioned. Not the least singular feature of this gigantic work was the political crisis under which it was conducted. So early as August 1790, the French Constituent Assembly, on the motion of Talleyrand, desired the king to write to the English government, to represent the advantage of the two nations uniting to adopt a common unit or standard of weight and measure, which it was proposed should be done by a joint committee of the Royal Society and the French Academy.[2] This application was probably never made, at least nothing came of it; but the Academy named their own committee, who, after discussing three sorts of natural standards,—the length of the pendulum in lat. 45° (first proposed by Huygens in his *Horologium Oscillatorium*), the length of a quadrant of the equator, and that of a quadrant of the meridian from the equator to the pole assumed to be elliptic,—adopted the latter, and this labour was committed to Méchain for the southern part, from Rodez to Barcelona (170,000 toises), and to Delambre for the northern, from Rodez to Dunkirk (380,000 toises). The southern arc was afterwards extended to Formentera in the Balearic Isles, and the whole length of the arc was found astronomically to be $12° 22' 12''\cdot6$. Two bases were measured (both by Delambre), one at Perpignan of 6006 toises, the other at Melun of 6076 toises (each about 7·3 miles). When the length of the former was computed by triangulation from the latter, the difference of the observed and inferred amount is said to have been only ten or eleven inches.

(166.) Its difficulties.

But difficulties greater than physical obstacles presented themselves to the completion of this vast work. The excited state of the public mind during the most frenzied period of the French Revolution rendered the simplest operations matters of suspicion. The nearer to Paris that the survey was carried on, the greater were the precautions necessary. Instruments were seized, assistants arrested, and night signals had to be totally dispensed with. "The coolness and intrepidity of Delambre, added to unexampled patience, were the principal means of extricating him from his difficulties: but his danger was often imminent, and he appears to have sometimes heard the dreadful words which, as an eloquent author has expressed it, were the last sounds that vibrated in the ear of many an unhappy victim." The operations were actually suspended for a time by a decree of Robespierre and his colleagues, who deposed Delambre, along with Laplace, Lavoisier, Borda, and others, from the Commission of Weights and Measures, as being deficient in "republican virtues and their hatred of kings." They were, however, resumed, and Delambre had finished his share of the work long before his colleague Méchain, whose shorter task was conducted amidst a people rude and uneducated, indeed, yet far more to be trusted than were then those of the north. Méchain was apparently wayward and impracticable, somewhat too aged for so great a work, yet a really good astronomer. The want of agreement to within 3″ of two sets of observations for latitude at Barcelona, the southern end of the arc at that time, led him to the suppression of one of them, and he was tormented ever after by the consciousness of the evasion, which deprived him of the tranquillity necessary to resume and complete his work, which was done chiefly by Delambre after vexatious delays.[1] The error, which may be said to have cost Méchain his life, was probably owing to the instrument employed on this survey, the repeating circle of Borda, only fourteen inches diameter, with a rather weak telescope. The opinion generally entertained in Britain is, that the repeating circle was quite inadequate to the prodigious accuracy required of it, especially in the determination of latitudes. The errors of mere division are often trivial compared to those inherent in other parts of an instrument. Of these a deficiency of optical power, and the want of absolute security of the clamps, upon which the entire success of the principle of repetition depends, are amongst the most obvious. The arc was finally prolonged from Barcelona to Formentera by Biot and Arago in 1806. The conclusion of the survey was not destitute of the adventurous character of its commencement. The French astronomers ran many risks, underwent much suffering, and Arago narrowly escaped finishing his days in the dungeons of Spain.

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[1] Both anecdotes are told by Moll, who had them from Delambre.

[2] The two governments and their respective learned societies had already co-operated in 1784 for a survey to connect Paris and Greenwich Observatories.

Méchain, Biot, and Arago.

(167.) English Arc.

The English survey carried on by Roy and Mudge has been also noticed in the previous Dissertation, The arc from Dunnose to Burleigh Moor amounts to 3° 57′ 13″·1, the measured length to 1442953 feet. An arc of parallel was also measured from Dover to Falmouth. We shall say something of its later progress in the concluding part of this essay, but we have still to regret the postponed publication of the British Arc of the Meridian, which we have no reason to doubt will bear a favourable comparison with the work of Delambre. The practical appliances, the three-feet theodolite of Ramsden for horizontal angles, and the eight-feet zenith sector of the same artist for latitudes, were unequalled instruments, and contrasted in almost every respect with the light and portable apparatus of the French. By means of the former the *spherical excess* of terrestrial triangles was first observed as a fact. The results of the French and British arcs taken separately concurred in showing a local curvature in this part of the world altogether anomalous, the degrees rather shortening in the northern part of each arc. This fact, which must be imputed either to large local attractions, giving errors of several seconds in the determination of latitudes, or (less probably) to a local departure in our quarter of the world from the general or mean figure of the earth, sufficiently shows the futility of the proposed method of determining a natural, recoverable standard of length. When combined with the measures of Bouguer in South America and Lambton in India, and the revised arc (measured in the beginning of this century) of Svanberg and Melanderhjelm in Lapland, the French and English measures give a general ellipticity somewhat under $\frac{1}{300}$, which is probably as near the truth as local inequalities admit of the determination being made.

(168.) French trigonometric formulæ and tables.

To Delambre was confided the drawing up of the trigonometric formulæ used in the calculations of the survey, which were published in a separate work; De Prony conducting the laborious calculation of an altogether new set of logarithmic tables, with the aid of an immense staff of computers, the results of whose labour (still in MS.) are preserved at Paris in 17 folio volumes. Delambre carried his personal exertions so far as to compute his own triangles—which were also independently calculated by Legendre, Van Swinden, and Tralles.

(169.) Prize awarded to Delambre.

As an acknowledgment of his merit, the highest indeed in their power to bestow, the Institute of France decreed to him in 1810 one of the Decennial Prizes instituted by Napoleon. But the Emperor, though professing to be the warm encourager of science, suffered some meaner motive to interfere, and refused to ratify the decision. "Ce fut," writes Dupin, "un pas dans la route qui le menait à sa chûte." After the siege of Paris in 1814 Delambre wrote a characteristic letter to his friend Moll. The tranquil spirit which had braved the horrors of the Revolution was not to be moved by the sounds of the artillery of the allied armies. In spite of the cannonade which he heard from his library, he laboured from eight in the morning until midnight; and, conscious of rectitude, he feared little the revolution of circumstances, which changing dynasties might call forth. "Labour," he says, "occupies all my time and all my faculties."

(170.)

As Secretary to the Academy of Sciences for the

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[1] The history is minutely given by Delambre himself in his Biography of Méchain.—*Astron. du XVIII. Siecle.*

His impartiality—his death.

Mathematical Sciences, he had to make frequent reports on the progress of those progressive branches of knowledge, and to contribute memoirs of the most eminent academicians, both native and foreign. Both these duties he executed with his customary labour and fidelity. His private character was as amiable as his public career was distinguished. The tendency of his writings was constantly to enforce the historical credibility of the Scriptures, especially with regard to the most ancient astronomical records. The value of his testimony is increased by his unusual skill in philology. He died 19th August 1822, aged 73.

(171.) We reserve some farther remarks on the geodetic results of this period, and especially on the pendulum observations with which they were accompanied, for the fourth section of this chapter.

§ 2. Sir William Herschel.—*History of Sidereal and Telescopic Astronomy to 1820. Herschel as an Optician.—Planet Uranus—Solar Spots—Orbits of Double Stars—Nebulæ—The Milky Way—Sun's Motion in Space.*

(172.) Sir Wm. Herschel;

The eighteenth century was not, generally speaking, distinguished by original observations. The exceptions stand out with all the brighter lustre. Amongst these, the discoveries of Sir William Herschel occupy perhaps the foremost place. Arago has affirmed that Slough is the spot on the earth's surface signalized by the most numerous discoveries, and in a certain sense this is strictly true. No one, before or since (with possibly the exception of Mr Hind) has added so many new bodies to the known planetary system, and this at a time when such discoveries were rarer, more unexpected, and more difficult than now. His researches on the fixed stars are not of a nature to have their importance numerically estimated.

(173.) his extensive works;

Sir William Herschel's career was one of the longest and of the most sustained labour in the history of science. To have contributed papers—often several in one year—to the Philosophical Transactions for thirty-nine consecutive years, from 1780 to 1818, with but two exceptions, is a feat of astonishing perseverance; but if we recollect that many of these papers contain announcements of capital discoveries, that every one of them is stored with original matter, and that the author had already passed his fortieth year when he commenced the production of this astronomical library, we cannot withhold a tribute of the warmest admiration.

(174.) early history.

England cannot claim Herschel as her own, except by adoption. He was born at Hanover in 1738, and was one of a numerous family who supported themselves chiefly by their musical talents. William Herschel, the third son, came to England in 1759 with his elder brother, and after struggling with many difficulties, found himself in comparatively comfortable circumstances as an organist at Bath. In 1774 he had executed a reflecting telescope with his own hands, and soon acquired so much dexterity as to construct instruments of ten and twenty feet in focal length. In 1780 he contributed his first paper on the variable star in *Cetus* to the Royal Society, and the following year (13th March 1781) discovered the erratic body, which he at first took for a comet, but which proved to be a planet exterior to Saturn; the first addition therefore to the number of the primary planets since a period of an immemorial antiquity. So fortunate a success made the name of Herschel speedily famous, and he was effectively befriended by George III., who brought him to live near Windsor, and gave him a pension.[1]

(175.) From this brief sketch it will appear how great were the obstacles which Herschel had to vanquish before he became a man of science, and that, besides the claims to distinction already enumerated, his knowledge and his skill were acquired in spite of every disadvantage.

(176.) Division of Practical Astronomy into Telescopic and Instrumental.

Practical Astronomy naturally divides itself into two great branches, that which depends upon the use of the telescope merely; on the telescope and micrometer; and that which determines the absolute places of the heavenly bodies, and requires the aids of divided instruments and a well furnished observatory. In the century to which he belonged Herschel is the type of the telescopic observer, Bradley of the instrumental. The discoveries of Aberration and of Nutation by the latter may stand a comparison with any in the history of science, but the resolution of Nebulæ and the proof of the mutual connection of stars in binary systems are not less distinguished and original. Herschel would have gained a great reputation as an optician, merely by the wonderful improvement which he effected in the dimensions and magnifying power of telescopes, and by the skill with which he applied them to celestial observations. He would have stood still higher as an astronomer had he been merely the first observer of a new planet and of eight secondary ones, as well as of several comets, and the author of many nice observations on the physical appearance and constitution of the sun and planets; but his great glory was in sidereal astronomy, of which he laid almost the foundations, by means of discoveries which he fortunately lived long enough to see confirmed and enlarged beyond his reasonable hopes.

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[1] It may be doubted whether any other similar annuity was given at that period on scientific grounds alone, and it is difficult to estimate the amount of benefit thus conferred on astronomy, for nothing short of the entire devotion of a lifetime could have produced such results as we owe to Herschel. His proposal to name his planet after the Sovereign was a very natural expression of his gratitude at a period when no rule whatever existed on the subject. See an interesting letter from Herschel to Sir Joseph Banks (who was also a warm friend) in Weld's *History of the Royal Society*, ii. 146, *note*. Herschel was elected into the Royal Society 6th Dec. 1781.

(177.) In this brief sketch of Herschel's achievements (which in his own department may be said to embrace those of his age, for he had hardly an imitator, and certainly no rival) we shall, in the first place, condense into small compass what is to be said on the two former heads—his merit as an optician and as a planetary observer.

(178.) Herschel as an optician. To construct good telescopes is itself no easy art, especially if they are to be carried to a size and perfection previously unattained. To ascertain the best composition, whether of glass or metal, to melt and to cast it in the right way, is one branch of the art which may be called generally the *chemical* part. To fashion the lens or mirror correctly by grinding, and to fit it for optical use by giving it an exquisite polish, is a second step requiring a peculiar *mechanical* skill and perseverance. To mount the telescope effectively is another and entirely different problem in mechanics; and all these the amateur astronomer must be prepared to accomplish with *his own hands*, unless he command the services of practical opticians to an extent rarely to be bought. Amateurs have indeed seldom succeeded except with reflecting instruments, and Herschel acted very wisely in devoting himself to their improvement at a time when the success of Dollond with achromatic telescopes had rendered the Newtonian form unfashionable. The real secret of Herschel's success was his astonishing perseverance; his determination was to obtain telescopes of twenty feet focal length or more, and of a perfection equal or superior to that of the small ones then in use. He himself relates, that whilst at Bath he had constructed 200 specula of seven feet focus, 150 of ten feet, and about 80 of twenty feet; a proof of extraordinary resolution in a man of limited means and engaged in a laborious profession. By making so great a number he could select those having the most perfect figure, especially before he had contrived a method of obtaining mechanically a parabolic form, almost with certainty. This method was not divulged. He was justified in keeping his secret, whilst he made a handsome income from the manufacture of telescopes for sale. Lord Rosse and Mr Lassell have had the merit of publishing their methods, which by their results would appear to be at least equal to Herschel's.

(179.) Magnifying and illuminating power of telescopes. The usefulness of telescopes depends on two distinct qualities—magnifying power and illuminating power. The former may be gained indefinitely by diminishing the focal distance of the eye-glass; the latter can be had only by increasing the diameter of the object-glass or speculum, so as to collect the rays which fall upon a circle of large diameter from every point of the object examined. But in order that the whole light may be effective, the magnifying power of the eye-glass must be sufficient to condense the emergent pencil within the diameter of the pupil of the eye. The proportion in which these two qualifications are requisite to obtain the best results in astronomy is a matter involving nice questions both of theory and practice. Sir William Herschel did more than any one who preceded or followed him to solve them. On the whole, the illuminating power is perhaps the most important, whilst it is the most difficult of attainment; but in truth each class of telescopic objects have their own rule in this respect. Brilliant objects, such as Venus, and moderately bright stars, do not require large apertures; very feeble objects, as the remoter satellites and the nebulæ, require indispensably great illumination. Five satellites of Saturn were seen by Sir W. Herschel in his great telescope *by the naked eye alone*, that is, without the advantage of the magnifying power of a lens. On the other hand, Sir John Herschel tells us that the satellites of Uranus cannot be clearly made out without a magnifying power of at least 300, *whatever may be the aperture of the telescope.*[1]

(180.) Magnifying power used in Astronomy. The mention of magnifying powers is calculated to mislead rather than otherwise in comparing the efficient means of different astronomers. The magnifying power used by Galileo did not exceed thirty-two times the diameter. Huygens, who used aerial telescopes of immense length, pushed it to 163 times. Auzout is said to have given a power of 500 to one of these gigantic instruments of 300 feet in length; but it is easily understood that such achievements were little more than nominal, the mechanical difficulty of managing these instruments being excessive. Short professed to carry the magnifying powers of his Gregorian reflectors to 1200, but still they yielded only trifling fruits to astronomy. It required that such instruments should be made and used *familiarly*, not as objects of luxury of which but one or two were ever brought into actual use. Herschel applied even to his seven-feet Newtonian (his favourite and smallest working size, having 6·3 inches aperture) powers exceeding 2000. To his largest instrument (thirty-nine feet focus) was occasionally applied a power of 6500. The highest powers usefully employed with the gigantic achromatics of Pulkowa and of Cambridge (in America), do not exceed 1822 and 2004 times respectively.

(181.) Its limits. The motion of the earth and the troubled state of the atmosphere, especially in these climates, impose a speedy limit to the increase of magnifying power, unless in exceptional circumstances. The same objections do not apply to the increased aperture and illuminating power of telescopes. This consideration induced Herschel to construct his forty-feet reflector, the funds being advanced by the king, on the recommendation of the Royal Society. The speculum had a useful surface precisely four feet in diameter, the thickness three and a half inches, the weight when cast above 2000 pounds. The second or plane mirror having been dispensed with, the image was thrown to one side of the object-end of the tube by means of a very slight inclination of the speculum, and was there observed *directly* by a common eye-piece or single lens, the observer being thus stationed with his back to the object he is viewing. This vast instrument collected a cone of rays from a distant point between six and seven times larger than the twenty-feet instrument commonly employed by Sir W. Herschel, of which the aperture was 18·8 inches. This telescope was not frequently used, partly from the rarity of sufficiently steady weather, and from the difficulty of preserving the figure of the mirror under changes of temperature.[1] Its figure was also affected by flexure under its own enormous weight, and it has been found one of the greatest difficulties by those who have followed Herschel's steps to avoid this source of error. The forty-feet speculum has been religiously preserved by the filial care of Sir John Herschel, in whose possession the writer of these pages had the pleasure of seeing it, now many years since, in a state of high polish. It remains in a deposit hermetically closed, at Slough.[2]

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[1] Struve found that with a small telescope, magnifying three times, and having the same aperture with the pupil of the eye (0·2 inch), he could count nearly twice as many stars (accurately 1·83 times) as with the naked eye. This result, interesting on several accounts, deserves farther enquiry.—*Etudes d'Astron. Stellaire*, p. 85.

(182.) Space-penetrating-power of telescopes.

Herschel made an ingenious determination of what he called the *space-penetrating-power* of telescopes, by which he discriminated the relative distances at which a given fixed star would become invisible in his several instruments. It was grounded on the assumption that the visibility of the object depends, first, on the density of its light reaching the eye, and secondly, on the number of rays of that density concentrated in the image. The former quantity varies inversely as the square of the given distance, the latter directly as the square of the aperture of the telescope; the limiting visible distance therefore of the radiant body will be *simply as the aperture*. To this he applied corrections depending on the loss of light by reflection at the specula, and by transmission through one or more eye-glasses. On this scale the space-penetrating-power of the seven-feet Newtonian being twenty, that of the twenty-feet telescope (front view) was seventy-five, and the forty-feet telescope 192. These estimations, as we shall see, form an important step in Herschel's generalizations.

(183.) Herschel's discovery of Uranus (or *Georgium Sidus*)

Of new bodies belonging to our system he discovered Uranus and his six satellites, the two satellites of Saturn next to the ring, and several comets. He did not, so far as we know, even suspect the planetary character of Uranus, which he believed to be a comet. The honour of this appears to be due partly to Saron of Paris, partly to Lexell of St Petersburg. Arago supposes that Laplace had also a share, but the evidence on the whole matter is somewhat obscure. Unquestionably it was an exceedingly difficult matter to fix upon a correct orbit for a body moving with such extreme slowness within the limits of the first few weeks after its discovery, and its distance was far beyond what any one calculating a comet's path would readily assume. The original discovery was also a *fortunate* one, for but eleven days previously the planet was in a position apparently stationary. It has led to results of still higher interest by the prediction of the existence and place of Neptune from the irregularities of Uranus. The satellites move almost perpendicularly to the ecliptic. Strange to say, they remained for, I believe, more than half a century, unseen by any eye but that of their discoverer and his son: and two of them still stand recorded on the single authority of Sir W. Herschel. They are the least specks of light which optical power has ever made visible.

(184.) observations on the planets;

Herschel made many observations on the physical appearance of the sun, moon, and nearer planets, and the times of their rotation. Into these details we cannot now minutely enter. The papers which record them are characterized (like all those of the same author) by the faithful minuteness with which the observations are detailed, and by the mention of every influential circumstance by which the results might be affected. In the case of observations so exceedingly delicate as those of the planets, the astronomer has to keep up an incessant struggle between the anxiety to record *all* that he sees, and that of recording *nothing more* than he really and perfectly sees. One or two glimpses are not sufficient. Herschel at one time imagined that the new planet had one or more rings which unquestionably do not exist. His elaborate investigation of the figure, belts, and rings of Saturn, the incredible tenuity of the latter, and the fact of their rotation in $10^h\ 32^m$, were amongst the most interesting of his observations, and were illustrated by drawings made with remarkable care. The edge of the ring was seen in 1789, when it had totally disappeared in all but his forty-feet telescope, and he estimated that its thickness could not exceed 100 miles. How astonishing the magnitude and thinness of this stupendous circular plane, or rather series of flat rings! Some idea of it may be deduced from the fact that if the thickness of the paper on which this is printed be taken to represent that of the rings, their greatest diameter would correspond to nine inches. Observations on the other planets and on the moon we here pass over for want of space.

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[1] The *first* object viewed by Sir W. Herschel with his great telescope in 1789 was the nebula in Orion; possibly it was also the *last*, for he again observed it in 1811 (See *Phil. Tr.* 1811, p. 322).

[2] See Weld's *History of the Royal Society*, ii., 193.

(185.) on the Sun: I have reserved the observations on the nature of the sun to this place, because everything leads us to assimilate the nature of the sun and of the fixed stars. The belief that the luminous disk of the sun is a *photosphere* or luminous atmosphere of great tenuity surrounding a globe of comparative density and darkness, was long anterior to Herschel, and in fact due to Dr Patrick Wilson of Glasgow, whose admirable paper on this subject was published in the Philosophical Transactions for 1774, in which he explains the phenomena of the solar spots by apertures in the luminous atmosphere, discovering the dark nucleus below, and some shell or shells of intermediate brightness which form the penumbra.[1] These conclusions were most clearly and ably deduced from a careful observation of the changing aspect of the spots, as they move by the solar rotation from the centre to the edge of his disk. It is to be regretted that Herschel does not more pointedly refer to the discoveries of Wilson, which were more than twenty years antecedent to his first paper on the subject, and with which he could hardly fail to have been acquainted. A similar remark applies, in a less degree, to his papers generally, which rarely contain references to the observations and speculations of his predecessors. Herschel adopted Wilson's hypothesis almost literally, and his long series of patient observations on the sun, made with high powers and at an eminent risk to his eyesight, enabled him to classify the singularly varied appearances of that wonderful orb, and to draw some probable conclusions from the excessive rapidity and seeming tumult of the exterior portions of it. That the *photosphere* is strictly gaseous he rendered very probable, an inference confirmed by the direct observations of Arago as to the unpolarized character of its light. The singular disclosure of faint red prominences extending far beyond the disk, and observed in the total eclipses of 1842 and 1851, shows that there is still much which regards the mysterious nature of the sun within reach of direct observation; and the same may be observed of the direct experiments lately made on the heat and light of different parts of the disk, which diminish to one-half between the centre and the edge, and appear to attain a maximum at the solar equator.

followed Patrick Wilson.

(186.) Herschel's sidereal discoveries. A convenient, though not a strictly chronological arrangement of Sir W. Herschel's *more important* sidereal discoveries and speculations may be made under the following heads:—

I. Of double Stars and their mutual connection.

II. Of the Nature of Nebulæ, and the so-called Nebular Hypothesis.

III. Of the Grouping of the Stars generally in space, and the significance of the Milky Way.

IV. Of the Motion of our System in space.

(187.) Double stars—orbital motion; I. *On Double Stars. Discovery of Binary Systems.*—Double stars were noticed as objects of curiosity even before the discovery of the telescope. The group of the Pleiades attracted attention from the earliest times. Amongst the earliest double stars carefully observed were ξ Ursæ Majoris (by Kirch, 1700); α Centauri in 1709; γ Virginis and Castor by Bradley (1718 and 1719); Mayer made a considerable catalogue of double stars in 1756. But Lambert first announced in 1761 (in his *Lettres Cosmologiques*) the probability of the mutual revolution of suns, in these remarkable words (speaking of clusters of stars), "It will perhaps be decided whether there are not fixed stars which make their revolutions in no long periods round their common centres of gravity." Mitchell, in 1767 and 1784, maintained the same views, but supported them by an application of the then young science of probability, hazardous in its principle, and unquestionably wrong in its numerical solution.[2]

(188.) failed to discover parallax. Sir W. Herschel commenced his observations on double stars with the hope of ascertaining the Annual Parallax in the manner previously indicated by Galileo and James Gregory; but, as in many parallel instances, whilst he failed of his main result, he discovered unsought a phenomenon more unexpected and probably more interesting. With the micrometrical means at his disposal, he entirely failed in detecting any *semi-annual* fluctuation of the interval between the members of the pair of stars, but he found (in some instances) progressive and continually increasing changes both in the relative position and distance of the two. He commenced his observations in 1779, but it was not until 1802 that he thought himself entitled to announce with confidence his discovery of the circulation of one sun round another, or rather of both round their common centre of gravity. Herschel's first list of orbital stars (*Phil. Trans.* 1803, where this splendid discovery was first published[3]) includes the chief examples now known; and they have *all* been confirmed. That of which the revolution is most rapid is ζ Herculis, which has a period of 31½ years, and consequently has revolved twice round since it was first observed, whilst the slow planet Uranus has not yet returned to the position of its first discovery. Herschel does not appear to have received a medal or other public recognition of this signal success.

(189.) Of the subsequent progress of this interesting inquiry we shall speak in the latter part of this chapter.

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[1] Flamsteed appears to have entertained in 1681 a somewhat similar opinion, as we find from a letter published (1855) in Sir David Brewster's *Life of Newton*, vol. ii., p. 103.

[2] See art. (85) and *note.*

[3] It was in fact distinctly though incidentally announced in his paper of 1802, though the proofs were given the following year. See *Phil. Trans.* 1802.

Greater precision has been in some respects attained, but little, if anything, added to the theory of double stars.

(190.) Nebulæ. II. *On Nebulæ and the (so-called) Nebular Hypothesis.*—The cloudy patches of mild light which are visible in clear but moonless nights in various parts of the sky are called nebulæ from their resemblance to light vapours moderately illuminated. Some regions of the sky abound more with them than others. The Milky Way presents to the naked eye a nebulous appearance extending over large tracts, and nebulæ more or less dense are frequent within and near its borders. These facts were well known from an early period. Some conspicuous nebulæ were described in the sixteenth century; that in Andromeda by Marius and the conspicuous nebula in Orion by Huygens. Halley added several, but the first descriptive catalogue of these objects was published by Messier in 1783 (in the *Connaissance des Tems*), and it forms the basis of the modern observations.

(191.) Classification of nebulæ; Sir W. Herschel took up the subject with his customary zeal. In 1786 he published a catalogue of 1000 nebulæ, which he had increased by 1802 to 2500. The first step to some appreciation of the nature of these extraordinary appearances was of course to classify them, and this Herschel did with such success that it may be affirmed that his classes remain the best at the present time, as *generally* representing the phenomena. Without entering into all his details, the following division embraces the main facts:—

A. Clusters of stars.
B. Nebulæ proper.
  α. Having a certain regularity, as 1. Circular or planetary nebulæ; 2. elliptic; 3. annular.
  β. Wholly irregular, as the nebula of Orion, the Magellanic clouds, &c.
C. Nebulous stars.

(192.) resolvable and unresolvable. *Remarks.* A number of faint stars produces a nebulous haze. This is a physiological fact. Parts of the Milky Way which present this appearance to the naked eye are at once shown by a telescope of small power to be composed of stars.[1] Patches which appear nebulous in such a telescope are shown by a better one to be composed of small stars. This is called the *Resolution* of a nebula. Such resolutions become more and more numerous as the apertures of telescopes are enlarged. Lord Rosse's telescope has resolved several which withstood the highest power of Herschel's. One inference might therefore be that *all* nebulæ are clustered stars, at a greater or less distance. Such an opinion is very general, and very plausible. It may on the other hand be observed that Herschel abandoned this his earlier inference, whilst, at the same time, he proceeded diligently with the resolution of successive nebulæ, by means of his powerful telescopes. He maintained on the contrary to the last that nebulæ belong to two classes, resolvable and irresolvable. The latter he believed to be composed of diffuse self-luminous matter, more or less condensed, whilst the milky light of the former is occasioned by the blended gleam of numerous close stars. With this difference, we find his views regarding the changes in the sidereal system and the progress of the *condensation* and *breaking up* of nebulæ, nearly the same in his earlier and later papers, particularly those of 1785 and 1811.

(193.) Herschel inferred their progressive condensation, The opinions of Herschel on these changes were the following:—Having observed that the more regular nebulæ (whether with a central star or not) presented almost invariably an appearance of gradually increasing brilliancy towards its centre, he was led to conclude that this is due to the aggregation of the self-luminous parts in virtue of their mutual gravitation; and the conclusion would so far be the same, whether the parts thus coalescing were in fact numerous distinct masses, or were like a vapour diffused through space. This was the process of *condensation*, which he inferred on the one hand from the law of gravity, on the other from the generally symmetrical arrangement of the luminous matter in nebulæ of the first class. In order to detect, by actual observation, the *progress* of condensation, he invented a simple and highly expressive terminology, indicating the *general* brightness, the *amount* of its gradation, and the *law* of its gradation from the circumference towards the centre. In whatever degree Lord Rosse's late observations may be considered to deprive nebulæ of the character of *symmetry* which Herschel had conferred on them, the general fact of an apparent condensation in a great majority of instances cannot be denied.

(194.) and breaking up in some cases. The *breaking up* of nebulæ (also described in his paper of 1785, as well as in his later ones) is likewise an *inferred* change anticipated in large irregular nebulæ, which usually exhibit bright spots or centres, with irregular vacant spaces, which sometimes seem like portions of a black and distant profundity seen through the rents of a nebulous veil. Herschel supposes that the luminous centres are also places of greatest attraction, and must gradually draw away the star-like substance from the rarer spaces.

(195.) Early anticipation of this hypothesis. It is curious that these speculations of Herschel (which are substantially common to his papers of 1785 and 1811) had been at least imagined at a very early period. Arago has pointed out that Tycho and Kepler conceived the New Stars of 1572 and 1604 to have resulted from *a sudden condensation*

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[1] The group of the Pleiades presents a peculiar instance. When the eye is turned full upon it, no more than six stars (as is well known) can be counted, but when the eye is turned aside through 10° or 15°, by a peculiarity of indirect vision by means of the lateral parts of the retina, the group appears a mass of nebulous light. This arises from an immense crowd of stars just below visibility, which, probably from the greater sensitiveness of this part of the eye, make a sensible though somewhat indistinct impression. This observation as to the Pleiades, and the inference which explains by it the seeming countlessness of the stars when viewed cursorily, were published by the present writer in Brewster's Journal for 1826.

of diffuse celestial matter, such as the Milky Way exhibits, and Tycho alleged that the new star was surrounded by an obscure space, half as large as the moon's disk. The history of Science scarcely presents a more curious anticipation.

(196.) Herschel's opinions on the distance of nebulæ;

One practical difference between the earlier and later views of Herschel on the nature of nebulæ, was as to their distance from our system. For if the milky aspect be due to a confusion of small stars, it is assumed that they must be almost incredibly distant. In his memoir of 1785, he estimates this distance at not less than 6000 or 8000 times that of Sirius. If, on the other hand, the nebulous appearance be due to a diffusion of starry matter, the distance may be that of any order of fixed stars; and this opinion derives weight from the evident connection of some nebulæ with stars round which they seem to cluster or hang almost like a drapery. Thus in 1811 he supposed that the nebula in Orion need not be more distant than a star of the 7th or 8th magnitude.

(197.) and their changes of form.

It appears from his paper of 1802 (page 500), that his ideas about nebulæ were then wavering. Between that time and 1811 he elaborated the nebular hypothesis, so far as it is due to him. He seems to suppose that starry matter was once in a state of indefinite diffusion. That during "an eternity of past duration" (Ph. Tr., 1811, p. 287) it has been "breaking up" by condensation toward centres more or less remote. That the Milky Way—or at least the nebulous parts which it contained—and the dispersed nebulæ, are the relics of this former state of things. That where condensation has gone on more energetically, we have nebulæ with a gradually or rapidly increasing brightness towards the centre;—if still more energetic, a nucleus, or it may be a planetary nebula;—next a nebulous star, which he supposes our sun to be, and the zodiacal light a relic of its nebula (p. 311);—finally, the completely formed stars may be assumed to be merely consolidated nebulæ. (See pp. 284, 285, 299, 310.) This condensation, he believes, must be accompanied by rotation due to the originally irregular distribution of the gravitating particles (p. 312–319).

(198.) Theory of condensation.

The *proofs* on which the whole of this cosmogony rests are, 1*st*, the *gradation* of appearances above described, to be collected from distinct objects in the heavens; and, 2*dly*, supposed changes observed by him in the nebula of Orion and others, during thirty years, and even during intervals of a few years. As to the last argument, it is admitted, we believe, by the best authorities, to be without weight. The changes of aspect of such curiously faint and graduated objects, even to the same eye using the same telescope, are numberless, and may be due to the slightest atmospheric and physiological influences. This test (as applied hitherto) is therefore generally rejected. Against the first proof much might also be urged, for which we cannot afford space. Its idea is essentially derived from the Natural History sciences, and I cannot help thinking that Herschel must have derived it from some one more conversant with these than with mechanical physics. This opinion is confirmed by a curious illustration which he uses in the same paper of 1811. "There is perhaps not so much difference between them" (viz., the whole group of nebular and quasi-nebular phenomena), "if I may use the comparison, as there would be in an annual description of the human figure, were it given from the birth of a child until he became a man in his prime" (p. 271).

(199.) Laplace's nebular hypothesis—connected with Herschel's.

A theory or hypothesis in some respects similar had been previously expounded by Laplace in the concluding chapter of his *Systême du Monde*. At least it so far resembles it, that he puts forth Tycho's notion of the star of 1572 being a condensation of a widely-spread stellar atmosphere (without, however, naming Tycho), and supposes that our solar atmosphere might also once have extended to the limit of the system, and that the planets were thrown off successively in the form of nebulous rings (subsequently condensed into spheres) from the equatoreal parts of this vast revolving mass during its contraction. He ascribes to Saturn's ring a like origin. It required all the authority of a name like that of Laplace to circulate a theory so bold, if not extravagant. He adhered, however (at that time), to the old idea of the constitution of nebulæ, which he considered to be composed entirely of stars, and to be at once the most distant and the most massive aggregations of matter in the universe. Herschel could hardly fail of being acquainted in 1811 with Laplace's views, and they probably in some degree influenced his own, particularly as to the cause of the rotation of his condensing suns. But he prudently reserved his hypothesis for sidereal objects, and did not deduce from it a planetary cosmogony. In the later editions of the *Systême du Monde*, Laplace quotes Herschel's observations in confirmation of his views, adopts the notion of a diffuse nebulous matter, and considers that an hypothesis arrived at by a "remarkable coincidence" in opposite directions, is thereby invested with a great probability.

(200.) Doubts regarding it.

Even Herschel's more limited conclusions have been very dubiously received, and notwithstanding the weighty adhesion of Humboldt and Arago to them, it may be affirmed that natural philosophers generally are content to leave the solution of this cosmical problem to that distant posterity which alone can hope to witness unequivocal evidence of *progressive* change in those wonderful objects.[1]

(201.) The constitution of the starry heavens, and of the Milky Way in particular

III. *Of the Grouping of the Stars generally in Space, and the Significance of the Milky Way.*—The earlier astronomers, and particularly Halley, had the idea that the nebulæ—which abound so remark-

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[1] The most intelligible account of the nebular hypothesis, in its least objectionable form, will be found in Sir John Herschel's *Outlines of Astronomy*, Articles 870 to 872.

Kant, Lambert, Wright.

ably in the Milky Way, and which may in some sense be almost said to compose it—are the *parent-matter* of stars, whilst stars abound in their neighbourhood, or seem partly to compose them, in a state of incredible aggregation. That the mass of sidereal matter composing the Milky Way (which forms an irregular girdle round the whole heavens[1]) has some special reference in its locality to our solar system, was also an early idea, which, towards the middle of the 18th century, had attained to something like a definite speculation in the minds of Kant, Lambert, and other philosophers, chiefly those of Germany. Its origin is perhaps traceable to Thomas Wright of Durham[2] (1742), who affirmed that the Milky Way is a projection on the sphere of a *stratum* of stars, in the midst of which our Sun and system are placed—somewhat excentrically, however, towards Sirius.

(202.) Herschel's "gauges."

I do not know whether Sir W. Herschel derived his first ideas on the subject either from English or German authors. His customary silence (which is to be regretted) on the history of his discoveries, leaves us in doubt of his originality. Be this as it may, he proceeded to test the reasonableness of the speculation, in that definite and thorough manner which was very characteristic of his genius. He proceeded to number the stars after a fashion which, if the early attempt of Hipparchus was pronounced in its day impious, might well have been accounted, even in Herschel's age, impossible. To use his own bold expression, he *gauged* the heavens, by counting the whole number of stars visible in the field of his 20-feet reflector as many times as possible, and in every region of the sky which was visible from Slough, distinguishing the results of each region. As it was impossible in one lifetime to accomplish the entire survey (for the complete sphere contains 883,000 fields of 15′ each in diameter), he took an *average* for each region, and thus determined the general population of the sky in all directions. The result more than confirmed the suspicions of Wright and Lambert, and demonstrated a remarkable, and, on the whole, a steady law of decrease, from the central zone of the Milky Way in opposite directions, until we reach two poles, one in the Southern, the other in the Northern hemisphere, which are the localities poorest in stars.

(203.) Plenitude of stars in different regions of the sky, as observed by Sir William and Sir John Herschel.

This DISCOVERY (for it well deserves the name), which assigns a Law to the distribution of the entire visible bodies of the Universe in space, is surely one of the greatest which man has ever attained. The simplicity of the means by which it was reached, and the amount of mere mechanical and arithmetical labour which forms its sole basis, and constitutes its essence, is a powerful lesson of how little mankind has a right to scorn the humblest means of knowledge, or to attach the prerogative of genius only to the lofty flights of imagination and speculative philosophy.[3] This triumph belongs to Herschel alone; his successors have commented upon and scrutinized his results; his son has "gauged" the Southern Hemisphere, with like results; but the original result is substantially confirmed. We may therefore anticipate so far as to quote the numbers denoting the "plenitude" of stars as we recede from the equator of the Milky Way in either direction, *first*, as calculated by Struve[4] and Sir John Herschel, from Sir William Herschel's observations in the *Northern* hemisphere; *secondly*, as calculated for the *Southern* hemisphere by Sir J. Herschel, from his own observations at the Cape of Good Hope.

Limits of Zone, reckoning from Equator of Milky Way.	*Average Number of Stars visible in 20-feet Reflector; Aperture 18·8 inches; Field 15′ diameter.*	
	N. Hemisphere (Magn. Power 157.)	S. Hemisphere (Magn. Power 180.)
0°– 15°	53·4	59·1
15 – 30	24·1	26·3
30 – 45	13·6	13·5
45 – 60	8·2	9·1
60 – 75	5·4	6·6
75 – 90	4·3	6·0

This table shows the extreme condensation of the stars round the "Galactic" equator; indeed Struve carries the average "plenitude" of the field as high as 122 stars in that plane itself.

(204.) According to Herschel's views, the whole visible firmament of stars belongs to the nebula of the Milky Way, of which our own system forms an infinitesimal part. In his paper of 1785, on "the Constitution of the Heavens," he inferred that the general form and comparative limits of this cluster of stars might be found from his "gauges," by supposing that his telescope brought into view every star between the spectator and the surface of the cluster. Supposing the stars to be *uniformly* distributed within the cluster, it is easy to see that the number counted in a conical space, having an angle of 15′ at its vertex, would give the *height* of the cone, or the depth to which the spectator is immersed in the cluster, in that particular direction; and thus he endeavours to assign the solid form of the cluster and its dimensions, in terms of the distances

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[1] Its plane is inclined about 63° to the Celestial Equator: its nodes are in 0^h 47^m and 12^h 47^m of Right Ascension.

[2] In his *Synopsis of the Universe*, a rare work. See Professor De Morgan's account of Wright, in the Philos. Magazine for 1848, xxxii., p. 241. Wright believed that the Milky Way was a congeries of stars of a particular form, which it owes to a rotation of the whole round some central point.

[3] Another remark, perhaps, deserves to be recorded. Had Hipparchus and his followers been deterred by the threatened charge of impiety from making a catalogue of stars, how great the loss would have been, not to science alone, but to our estimate of the order and magnificence of creation. The telescope only increased our knowledge of the number of worlds, without really enabling us to approach to their limits:—the gauges of Herschel, which he at first supposed to reach to the boundary of the *visible* firmament, proved to him at last that the wealth of creation was *unfathomable* by any measure he could apply to it. "Numbers numberless" appeared in those regions where the stratum of the Milky Way is most extended.

[4] *Etudes d'Astronomie Stellaire.*

(hypothetically uniform) between any two stars. But in his later memoirs, Herschel seems to have felt the insecurity of his conclusions, and that there is no reason, but the contrary, to believe in a uniform distribution of the stars; that, at least in some directions, the Milky Way is *unfathomable*, or its limits unattained even by the 40-feet telescope. (See his Memoir of 1817.) He therefore judiciously recurs to photometrical measures as the best criterion of the distance of the stars. The estimate of "the space-penetrating power" of his telescopes, already referred to (182), enabled him to infer the relative distances at which a star would become lost to vision aided by each telescope.

(205.) Relative distances of fixed stars. Calling the distance of a star of the first magnitude 1, and supposing that light takes three years to traverse it,[1]—

	Dist.	Light travels in
The distance of a star of the sixth magnitude (the limit of unassisted vision) will be	12	36 years.
Limit of 20-feet telescope (used in gauging)	900	2,700 ...
Limit of 40-feet telescope	2,304	6,912 ...
Limit of Lord Rosse's telescope (6 feet diameter)	3,436	10,308 ...

Yet none of these telescopes appear to touch the boundary of our nebula in the direction of its greatest extension, for fresh optical power still yields fresh harvests of stars.

(206.) All visible stars belong to the system of the Milky Way. In a direction perpendicular to the plane of the Milky Way, not only is the paucity of stars remarkable, but we seem to look out, as Sir John Herschel describes it, into a starless region external to the stratum. Sir W. Herschel concluded, in 1817, that the depth of the stratum in its least dimension is such as to include all stars down to those three times more distant than the naked-eye perceives. His son, 20 years later, infers, from the investigation of the southern hemisphere, that the distribution of stars is comparatively *independent of direction* for all those which are brighter than the 8th magnitude, and that it is by the influence of the hosts of lesser brightness visible in the 20-feet reflector, that the very remarkable law of condensation towards the plane of the Milky Way takes effect. He is therefore disposed to conclude that "our system is plunged in the sidereal stratum constituting the Galaxy, reckoning from the southern surface to a distance which corresponds to the light of a star of the 9th or 10th magnitude."[2]

These great and arduous enquiries occupied Sir William Herschel during nearly the whole of his scientific career, extending to almost half a century. His first observations (Struve remarks) dated from 1774, his last observations on this subject which have been published were of 1804, and his latest paper, still on the same topic, was in 1821, when he was almost on the verge of the grave. (207.)

Excepting the continuation of his labours by his illustrious son, little has been added to our knowledge of "the constitution of the Heavens" since his death. We shall, therefore, hardly recur to the topic in the latter part of this chapter. Some German astronomers of eminence have indeed tried to deduce from an assumed distribution of the stars in the Milky Way, the necessity of allowing that space is not perfectly transparent, and have even attempted to assign the law of extinction of light through the sidereal intervals; but having examined their reasoning with the best care I have been able to give it, I am bound to say that it appears to me very far short of conclusive.[3] (208.) Continuation of Herschel's researches.

IV. *Of the Motion of our System in Space.*—That the stars are not *fixed*, but have "proper motions," not explicable by the gyrations of our earth round its centre of gravity (which produce precession and nutation), nor by its revolution round the sun (on which aberration and parallax depend), was a fact first detected by Halley from a comparison of ancient and modern observations. Though small in amount, yet as it continually increases in the same direction, this Proper Motion becomes in the course of ages an important quantity. In 2000 years, Arcturus, μ Cassiopeiæ and 61 Cygni have moved $2\frac{1}{2}$, $3\frac{1}{2}$, and 6 times the moon's diameter. (209.) Proper motions of stars—Halley.

In 1748, Bradley (in his paper on Nutation) stated the probable explanation of these apparent motions (210.)

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[1] These startling results appear to be necessarily true, if the following assumptions be admitted:—(1.) That the stars have *on an average* the same brilliancy in all regions of space. (2.) That the light received from a star is inversely as the square of the distance; or that the laws of radiation and of *vis viva* are rigorously true, and that there is no absorption of light in space. (3.) That the visibility of a star is exactly as the quantity of light received from it in the telescope. Probably this last assumption is the least sure. We know that magnifying power (independently of illumination) affects the result.

[2] *Cape Observations*, p. 383.

[3] I ought perhaps to state that in this passage I have referred to the reasonings of M. Struve, contained in the latter part of his *Etudes d'Astronomie Stellaire.* Having taken some pains to follow the argument of that work, which professes to be "based entirely upon observation, without any arbitrary hypothesis," I was reluctantly led to the conclusion that M. Struve's assumptions, if tacit, were not the less arbitrary and questionable. Indeed it appears self-evident that no geometrical certainty can be attained as to the relative distances of the stars composing the Milky Way, but from some fundamental hypothesis respecting their magnitudes and distribution. I am persuaded that the popular writers and reviewers who have given additional publicity to the most striking and positive of M. Struve's conclusions, have (very naturally) done so on the strength of the author's well-deserved reputation as an observer, and without attempting to analyse his reasoning, which it must be owned is sometimes obscure. My objections to M. Struve's argument were put in writing several years ago (1850), but not published except in my lectures. It was only whilst correcting the proofs of these sheets (1855) that I saw for the first time a memoir by Professor Encke in the *Astronomische Nachrichten*, vol. xxvi., No. 622 (published in 1848), maintaining the same view of the invalidity of M. Struve's reasoning, and questioning the hypotheses (of which M. Encke reckons *five*) tacitly assumed by him. The Dutch Academy of Sciences (Haarlem) has proposed the points at issue between MM. Struve and Encke as the subject of a prize question.

Motion of the solar system in space—Bradley—Mayer.

to be the real displacement of our sun and system in space. In 1760 Mayer gave a list of 80 stars whose proper motions he determined by a comparison of Römer's observations. He conceived the possibility of determining the direction of the solar motion by the changing aspect of the constellations, keeping in view, however, that the effect is complicated by real independent movements of each individual star. Lambert and Mitchell entertained similar views, but carried them to no practical result.

(211.) Sir W. Herschel determines the direction of motion.

Here, then, Herschel appears on the field. He proceeded in 1783 to *do* what his predecessors had discussed the *possibility of doing*. His own observations were not available in a problem like this. Taking the best values he could obtain of the Proper Motions of only about 20 stars, he, with great sagacity and success, *divined* that the solar system is moving somewhere in the direction of λ Herculis, a point in the heavens whose right ascension is 257°, and north declination 25°. This result he arrived at, almost without calculation, by a mere consideration of the changing perspective of a multitude of objects amongst which the spectator moves. Mayer had compared the change to that seen when we walk slowly through a grove of rather distant trees. Those in front will seem to widen or expand as we approach, those behind will condense towards the point we are quitting. The greatest proper motions will be in the objects on our right and left as we advance. It is not to be supposed that we find in the stars the *exact* counterpart of this change of place. For each star may by its own absolute movement in space either conspire with or oppose the motion due to perspective. But a combination of the *whole* results will make apparent the direction of that part of the motion due to a common cause, that is, to the translation of our system in space. A cleverer approximation than Herschel's was never made. He returned to the subject in 1805, but there is reason to think that his first result was the more correct.

(212.) More recent researches on the same subject.

As nothing *essential* has been added to Herschel's discovery of the direction of the solar motion, we shall here refer once for all to the important *confirmations* which it has since received. Professor Argelander, availing himself in 1835 of the improved state of astronomy since Bradley's observations were made, and since their reduction by Bessel, considered the whole problem in a general and geometrical manner, including every well-determined proper motion[1] by means of appropriate equations of condition, which, being resolved by the method of least squares, give the direction of solar motion 261° 11′ of right ascension, and 30° 58′ of north declination, differing respectively about 4° and 6° from Herschel's first numbers. Perhaps a still more convincing confirmation was obtained by Mr Galloway (*Phil. Trans.* 1847), from the proper motions of stars of the southern hemisphere alone, which lead to a result nearly coinciding with the above.

(213.) Summary of Herschel's discoveries.

Sir William Herschel's leading discoveries in Sidereal Astronomy may therefore be reduced to these—the discovery of binary systems of stars and the orbits of several revolving stars; the discovery and classification of a prodigious multitude of nebulæ; the law of grouping of the entire visible firmament, and its connection with the great nebula of the Milky Way; and lastly, the determination of the fact of the motion of our sun and system in space, and the direction of that motion. Setting aside all that is valuable, ingenious, and noble in his farther speculations, and all that he contributed to the enlargement of our knowledge of the system of sun and planets with which we are more immediately connected, these positive discoveries will ever remain a magnificent trophy of his perseverance and success as a natural philosopher.[2]

(214.) His physical observations.

When his increasing years rendered the relaxation of his arduous course of telescopic observation advisable, whilst all his other faculties were in the highest vigour, he began to devote more attention to physical enquiries less directly connected with astronomy. The nature of the emanations of light and heat proceeding from the sun was a matter on which he was forced to speculate in connection with his ideas of the sun's constitution; and even the practical enquiry as to the kind of dark glasses best fitted for defending the eye in observations of that nature, led him, in conformity with his usual habit, to a large series of experiments on solar heat, and its transmissibility through glasses of different colours, and other bodies. In the progress of these he was led to examine *the heating power of the different rays of the spectrum*, and consequently the refrangibility of heat. He then arrived at the real discovery that the place of greatest heat in a spectrum formed from the sun's rays by a flint-glass prism is considerably *beyond the extreme visible red ray*. But we shall return to this result in connection with the history of radiant heat. He also made some experiments on

Heating rays of the spectrum.

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[1] A small star in Ursa Major (1830 of Groombridge's Catalogue) has an annual proper motion of 6″·97; the star 2151 Puppis, is the greatest known, being 7″·87.

[2] No historian of science, or biographer of Sir W. Herschel, can fail to acknowledge with gratitude the important assistance afforded by MM. Arago and Struve to a compendious acquaintance with his writings and discoveries; the former by his article on Herschel in the *Annuaire du Bureau des Longitudes* for 1842, the latter in his *Etudes d'Astronomie Stellaire*. While acknowledging my obligations to these works, I shall not be suspected by any careful reader of having dispensed with a reference to the original memoirs; still less of having adopted without examination the conclusions of these eminent authors, from whom, indeed, on some important points, I differ entirely.

the colours of thin plates, but to these he did not attach much importance.

(215.) Herschel's character; The philosophical character of Herschel is almost included in what precedes; but we will endeavour to sum it up in a few words. He united in a remarkable degree the resolute industry which distinguishes the Germans, with the ardour and constancy of purpose which has been thought characteristic of the Anglo-Saxon. From his native country he brought with him a boldness of speculation which has long distinguished it, and it is probable that he had also a vigorous and even poetic imagination. Yet he was ever impatient until he had brought his conjectures to the test of experiment and observation of the most uncompromising kind. He delighted to give his data a strictly numerical character. Where this was (by their nature) impossible, he confirmed his descriptions by reiterated observation, in different states of weather, with different telescopes, apertures, and magnifying powers; and with praiseworthy fidelity he enabled his readers to form their own judgment of the character of his results by copious and literal transcripts from his journals. On his claims to originality we are unable in all cases to decide, owing to almost his only literary fault, that of rarely alluding to the writings of his predecessors or contemporaries, even so far as to acknowledge their existence. The discovery of binary systems is probably that which was most absolutely his own; but even supposing the speculations of Wright, Lambert, and Mitchell were not unknown to him, this would diminish but little the substantive merit of having devised and executed the means of removing them from the regions of almost metaphysical abstraction to that of concrete reality.

(216.) his long life, His long and tranquil but ever active life corresponded happily to the nature of his pursuits, which required an absolute devotion of his time, and the means of instituting comparative observations after an interval of many years. There are not many philosophers who could have expected within their lifetime to see at least one pair of suns complete their mutual orbit.

(217.) and decease. Herschel's career at length drew to a close. He died peacefully at Slough, near Windsor, where he had resided throughout the greater part of his life, at the age of eighty-three, on the 23d August 1822, one year only after the publication of his latest memoir in the Transactions of the then recently formed Astronomical Society, of which he was the first President.

§ 3. Bessel—Mr Airy—*Modern Observatories. Fixed Star Catalogues—Planetary and Lunar Observations.*

(218.) Modern astronomical details since 1810. As we approach the most recent period of the history of astronomy, I feel the increasing difficulty of a due condensation and selection of the interesting matter which claims our notice. Astronomy has been so generally and so zealously cultivated, that it seems almost invidious to select a few names and a few leading discoveries as the topics of discussion. It is, however, necessary to do so, and I shall be guided by the single aim of trying to specify impartially those individuals who have by their labours given most of the impress of the age to the science which they represent. In a subject like this, of almost infinite detail, the reader is not to expect a list of the names of all discoverers and improvers; it is not our business here to dwell upon mere labours of *precision*, to which so large a part of the most useful industry of astronomers is devoted; but to show the *spirit* in which these labours must be undertaken, and the *general results* by which they enrich the knowledge of the passing generation.

(219.) Practical astronomy in England. In the first section of this chapter we have sketched (in connection with the name of Maskelyne) the state of accurate astronomy in fixed observatories, down to about the year 1810. Since that period the multiplication of observatories has been very great. There has been a great improvement in instruments and in the methods of using them. But there has been an incomparably greater advance in the methods of extracting trustworthy results from observations made with due care. The art of dividing instruments was carried to great perfection in Great Britain by Graham and Bird, but their preference of the quadrant to instruments of a circular form (introduced long before by Römer) retarded the progress of astronomy. Foreign observatories in the early part of this century (as in the last) sought their divided instruments from London; Piazzi and Bessel worked with English circles. Troughton was as an artist the worthy successor of Ramsden; and even to the present time British astronomers, at least, do not admit that the nice contrivances and beautiful workmanship of Repsold and of Merz in Germany, or of Gambey in France, have produced instruments worthy of more confidence than those which have been constructed at home. In the improvement of object-glasses for telescopes, however, Germany and France bear away the palm, although for many years Dollond supplied Europe with his achromatic telescopes. With regard to constancy and fidelity of observation, whether in fixed observatories or in maritime and geographical expeditions, English astronomers have never been backward; and the reputation of Greenwich Observatory in this respect (and also in the punctuality of publication) has, as we have stated elsewhere, earned the approbation and gratitude of all Europe.

(220.) But here our praise of British astronomy must

Reduction of observations long neglected.

pause. Until very recent times, with few exceptions, our observers, however industrious, have merely used mechanically the apparatus put into their hands by intelligent and conscientious artists, who yet, never having occasion to apply their own handiwork to the purposes for which it was made, could not be expected to detect deficiencies of construction, nor to possess the mathematical knowledge required to remedy them. To determine in a complete and independent manner the errors, not only of adjustment, but also of construction of the instruments, and to correct them by calculations (deduced when necessary from frequent observations of their amount) is now felt to be the duty of the astronomer himself. This improvement (though, as we shall see, already partially practised even in England) was mainly due to Bessel, whose name we have placed first at the head of this section. But astronomy owes to him much more than this. He first showed that it is part of an intelligent astronomer's duty, not only to *observe* stars and planets, but to undergo the vastly greater labour of comparing his results with the best theories of his time, and of improving as far as possible those theories, so as to hand over each branch of science to his successor in a more perfect state than that in which he found it. In all these respects practical astronomy commenced a new epoch in Germany, and on this account principally we place the name of Bessel in a conspicuous rank.

(221.) Bessel—his early labours.

Friedrich Wilhelm Bessel was born at Minden on the 22d July 1784. He was destined for a mercantile career; and it is an interesting fact that it was the expectation of an appointment as supercargo on a commercial voyage which led him to study navigation and astronomy, and finally induced him to devote his entire energies to the latter science, in which he received every encouragement from the amiable Olbers, who fortunately inhabited Bremen, where young Bessel was engaged in business. He commenced his astronomical career by reducing Harriott's observations of the comet of 1607, and was thereafter appointed assistant to Schröter at the observatory of Lilienthal. In 1810 he was removed by the Prussian government to the charge of the observatory about to be erected at Königsberg, where he spent the remainder of his life, and which he very speedily raised by his labours to almost the first rank of European observatories. In fact, he possessed, in a singular degree, the qualifications for directing a great observatory; including a thorough acquaintance with the use of instruments, with the theory of astronomy in all its branches, with the higher mathematics, and also the art and practice of calculation, as well as with many allied branches of natural philosophy.

(222.) His *Fundamenta Astronomiæ*:

The work by which he is perhaps best known, the *Fundamenta Astronomiæ*, is not grounded on his own observations, nor even those made in the same century, nor in his own country, but, what may appear singular, upon the observations of Bradley at Greenwich in 1750 and some following years. In reality, no better observations had been then made. The instruments had undergone no material change during the long and industrious, though not splendid, career of Maskelyne; and Bradley was beyond question the most accomplished astronomer of the 18th century. Let us record it as a fact for the encouragement of conscientious labour in the service of science, that these precious records of the state of the heavens, of which the value seemed unknown to a whole succeeding generation (so that they were not even printed in a crude form until nearly fifty years after they were made), were disinterred, so to speak, by an illustrious foreigner, and in course of time made the basis of what, in respect of precision and method, might be called a new astronomy. Bessel was assisted in this work by a grant from the British Board of Longitude.

—reduction of Bradley's observations.

(223.) Special objects of this work.

The observations especially considered by Bessel are those of the fixed stars. To apprehend their importance, we must recollect that the foundation of an accurate knowledge of the orbits, and of the perturbations of the Solar System, not to mention less apparent but not less remarkable changes of place in the stars themselves, consists in rendering perfectly comparable observations of position at one time with those made at another more or less remote. Now, not only are our transit instruments and quadrants, and circles, and clocks, affected with errors more or less unknown, so that the registered figures require correction; but, in consequence of Refraction and Aberration, we see no body whatever exterior to the earth in its real visual position; and this visual position, when found, is affected by Parallax. Besides all this, the grand points of reference in the sky, the Pole and the line of Equinoxes, are undergoing perpetual, though small, changes of position:—the first star of Aries had already, in the time of Hipparchus, wandered from the point of intersection of the Equator and Ecliptic;—consequently, longitudes and right ascensions have to be reckoned from a directional line in space altogether imaginary. The pole of the heavens wanders amongst the stars, in consequence of Nutation—the obliquity of the Ecliptic is itself changing; and, to crown all these causes of perturbation and seeming unsteadiness, the stars called fixed have (as we have formerly seen) peculiar and individual displacements not accounted for by any of the preceding causes of change. In short, nothing is fixed and comparable, except our measure of time. The length of the sidereal day is subject to no secular variation. The bases of Astronomy,—the *Fundamenta Astronomiæ*,—then, evidently consist in the perfect evaluation of all these varying elements, so that the stars, if not really fixed, may become, for us at least, *virtually* so,—that by their aid the position of the fundamental directional lines of the sphere may at any time be found, and the relative positions of the stars themselves. After this it is easy to refer the places of wandering bodies to standard points.

(224.) Results. Bessel's work includes a methodical reduction of the places of above 3000 stars observed by Bradley, and an investigation of the sun's apparent path, together with a full discussion of the principles and application of every correction, instrumental and uranographical, which such observations require, and which are applicable to all others of the same kind. It includes, therefore, dissertations on some of the most delicate points of Astronomy, and "Constants" for the different corrections, which, with slight variation, have been since employed in every observatory. Bessel devised also a remarkably simple mode of finding for each star the varying corrections of its place. The *proper motions* of the stars were also determined for the first time with approximate exactness, by comparing Bradley's places with more modern observations.

(225.) Bessel's own observations. In subsequent years (the *Fundamenta* were published in 1818) Bessel contributed to the science of astronomy numerous and regular observations of the heavenly bodies; the Annals of the Königsberg Observatory were regularly published from 1814, being (I believe) the first foreign establishment which followed the example set by Maskelyne at Greenwich, with the important addition of systematic reduction.

(226.) His numerous works on astronomy. Of the subsequent labours of Bessel we must speak very shortly. The determination of the parallax of the star called 61 Cygni, perhaps the most original and important of these, we shall refer to another section, where we shall compare it with the results obtained by other astronomers. He made interesting physical observations on Halley's comet at its return in 1835; he prepared the materials for a very extended catalogue of fixed stars, arranged in zones, more recently published by Professor Weisse. In connection with the theory of the pendulum as a measure of gravity, he repeated and extended Newton's important experiments on the uniformity of the gravitating force on all kinds of matter; he applied a new correction to the vibrations of the pendulum, and improved the method of observing them correctly; and he discussed with his habitual mathematical skill and elaborate perseverance the figure of the Earth, from the whole of the then existing observations; whilst he also directed an operation for connecting the Russian triangulations with those of western Europe,—a delicate task, which he performed with consummate skill. It will thus be seen that (without mentioning a host of minor works and memoirs) there was hardly a great department of Astronomy in which Bessel did not take a distinguished part. Even the discovery of Neptune, by calculation from the irregularities of Uranus, was contemplated as a practicable problem by the veteran astronomer in his later years. He died on the 17th March 1846; therefore only a few months previous to the publication of MM. Leverrier and Adams' discoveries, and their triumphant consummation by M. Galle.

(227.) Pond, the Astronomer-Royal, an excellent observer. Even before Bessel's career as an astronomer had properly commenced, Pond, in England, had anticipated, in a good measure, the improvements in practical astronomy to which we have referred in the beginning of this section. Already, in the earliest years of this century, he had made observations at his private residence with a comparatively small circular instrument by Troughton, which led him to detect the gradually increasing errors of Bradley's quadrant still in use at Greenwich, and to recommend the adoption of complete circles (disused since the time of Römer) and the specific examination of errors of division. These principles he carried out at Greenwich, to which establishment he was afterwards appointed. His very indifferent health prevented that incessant activity which the management of a first-rate observatory requires; nevertheless, he is justly regarded as one of the chief reformers of the practical astronomy of those days.

(228.) Succeeded by Mr Airy. His successor, Mr Airy, has distinguished himself by a more active career. Endowed with very uncommon abilities, and with great physical powers of endurance, he has, from his youth, been ever foremost not only in promoting, in every one of its departments, his favourite science of Astronomy, but also many other allied subjects, particularly Optics, to which we shall have occasion to refer in another section.

(229.) His numerous labours in physical and practical astronomy. Born in the county of Northumberland in 1801, Mr GEORGE BIDDELL AIRY acquired great distinction at Cambridge, where he graduated in 1823, and was appointed to the charge of the Observatory there in 1828, after the death of Professor Woodhouse, a person sincerely attached to astronomy and well skilled in it, yet one who did not succeed in imparting much interest either to its theoretical or practical departments. Mr Airy engaged in the important investigation of a new irregularity in the motion of the Earth and Venus, to which I have referred in the chapter on Physical Astronomy (114), and at the same time he undertook to publish his own Observations in regular annual volumes, including a complete comparison of the results with the best tables, thus presenting at a glance the existing errors of theory. This practice he introduced at Greenwich on succeeding Pond there in 1835; and he has pursued it ever since. But not contented with rendering the annals of the National Observatory a correct reflection of the state of the heavens in his own day, and also of the condition of Astronomical Theories, he did not rest until he had performed for the observations of his predecessors the same service, and thus produced a series of comparisons of the observed and calculated places of the moon and planets, unexampled for extent and accuracy. Beginning with Bradley's Observations in 1750, he investigated and applied all the instrumental and uranographical corrections to each, as Bessel had done for the observations of the sun and fixed stars, and then calculated the tabular places for the same instants of time. This last, especially in the case of the moon, was a truly formidable task. The whole labour was methodically performed at the expense of government by a staff of no less than sixteen computers, under Mr Airy's vigilant superintendence, and it extended, first and last, over the space of a dozen years. The results, printed in the most compendious form, fill 2200 quarto pages. One consequence of this systematic reduction was, that MM. Leverrier and Adams were separately provided with the places and errors of the Tables of Uranus necessary for their great investigations; and the Lunar Theory has been enriched with Mr Hansen's latest corrections through the same facilities. The final corrections of the co-efficients of the Lunar Tables are concisely stated by Mr Airy in a paper addressed to the Royal Astronomical Society.

(230.) The new Greenwich Transit Circle.

Like Bessel, Mr Airy is thoroughly acquainted with the theory and practice of mechanics; and he has applied his knowledge both to the improvement of clocks and of proper astronomical instruments. A great and apparently successful experiment of the latter description is now taking place at Greenwich. A meridian circle (combining in effect a mural circle and transit instrument) has been erected, of great size and optical power (6 feet circle and $8\frac{1}{4}$ inch object-glass). But the novelty of the apparatus is its great weight and strength. Hitherto artists and astronomers have sought to avoid the evils of unsteadiness and flexure principally by the elaborate framing and trussing of light materials (chiefly brass tubes), and (in Germany especially) by an elaborate system of counterpoises. The new Greenwich circular instrument is constructed of as few pieces as possible, of great strength and weight, and in great part of cast iron. The whole was elaborated and prepared for dividing in an engineering workshop, and with the powerful and accurate tools which modern engineers use. A man might stand upon the axis without producing the smallest bad effect. It is understood that the result is perfectly satisfactory as to steadiness and stiffness. Mr Airy has likewise invented and erected a new and most ingenious zenith tube (acting by reflection) for ascertaining the place of γ Draconis, a star which, at its superior culmination, crosses the meridian of Greenwich almost in the zenith.

(231.) There are few projects for the improvement of astronomy in the last twenty years in which Mr Airy has not been a counsellor or participator. He has at all times given efficient aid to those engaged in the pursuit of science; and has been himself the first to import from America and to establish on a great scale the method of recording observations by means of a galvanic pressure produced on a sheet of paper surrounding a cylinder; which cylinder is moved in a perfectly uniform manner by means of a connection with a clock producing uniform motion on the principle of the conical pendulum. By means of a simple contrivance the tracer follows a slightly spiral line, so that one barrel may include many hours of continuous observations. He has also established galvanically time signals, and employed them for the determination of longitudes. Besides all this, he has taken part in furthering geodetical measures, in regulating the national standards of length, and in promoting in various ways the collateral sciences. He contributed to the *Encyclopædia Metropolitana* a most able analysis of the methods for determining the Figure of the Earth, and his conclusions have been very generally adopted. In the same publication he has given a theory of the Tides, already referred to (78, 82). The public and his own university are indebted to him for several very valuable text-books on mathematical physics.

Introduction of galvanic method of observation at Greenwich.

(232.) Magnetical and meteorological observations.

During his incumbency at Greenwich, Magnetical and Meteorological Observations have been added to those of Astronomy, and engage the time of four regular assistants in that department. The astronomical assistants amount to six, besides occasional computers. It may safely be affirmed that there is not a public establishment in a more complete state of efficiency than is Greenwich Observatory at this moment; and that its traditional reputation, expressed in the emphatic eulogium of Delambre, Art. (150), runs no risk of deterioration under the direction of Mr Airy.

(233.) Other observatories.

Our limits will not allow us to refer to the numerous private observatories in England and public ones abroad which are contributing useful elements to the promotion of astronomy. It is not too much to say that the activity of Greenwich has set a generally good example. The observations at Oxford and Edinburgh have long been reduced on a systematic plan; those at Cambridge had been already so treated. The establishments where sidereal astronomy is particularly cultivated will be noticed in another section.

§ 4. BORDA—KATER—BAILY. *The Figure of the Earth from Pendulum Observations—"Reduction to a vacuum;"* Mr Stokes. Colonel EVEREST—M. STRUVE. *Latest Measures of the Earth.* M. Foucault's *Pendulum Experiment.*

(234.) Figure of the earth resumed.

In the first section of this chapter I have mentioned the progress made in determining the figure of the earth by measurements of its surface in the early part of this century. I shall now advert briefly to the employment of the pendulum for the same purpose.

(235.) Clairaut had published in 1743 a very remarkable theorem which connects the force of gravity in any

Connection of gravity and the figure of the earth—Clairaut's Theorem.

latitude with the compression of the terrestrial ellipsoid.[1] The pendulum is the readiest and most accurate means of determining variations in the force of gravity; the repetition of its oscillations enabling the observer to ascertain their average duration with extreme nicety. The more rapid the oscillation the greater is the force of gravity, because the heavy body is more quickly drawn into its lowest position. Two sets of observations, made in different latitudes, would, rigorously speaking, suffice to determine the polar compression, supposing the earth to be a geometrical ellipsoid, and composed of homogeneous and concentric layers; a larger number would serve to test the accuracy of these assumptions, and would, at all events, be imperatively required to eliminate the errors of observation.

(236.) Early pendulum observations.

It might be supposed that to swing a pendulum, count its vibrations, and measure its length, is a very easy thing. Experience shows that a more difficult practical problem can hardly be proposed. Those persons, therefore, who have in a good measure overcome the difficulties, are to be regarded as promoting materially an enquiry which has always ranked amongst the most interesting connected with astronomy. Some of the observations of the eighteenth century, especially those of Lacaille at the Cape of Good Hope and of Phipps in the Arctic Regions, appear to have been made with much care; but the French astronomer Borda seems to have given the initiative to observations of a higher degree of accuracy, and his methods were ably carried out in connection with the great French meridian arc, by M. Biot, who even extended his stations to the Island of Unst in Shetland.

(237.) Borda improves the method of making them.

Jean Charles Borda, who was born in 1733 and died in 1799, was devoted to the promotion of the exact sciences, and contributed in an eminent degree to the precision attained in physics and astronomy towards the close of the last century. The name of Borda deserves a record in the history of science, since it has been said of him, by no less an authority than Dr Young, that "he seems to have possessed a considerable share of that natural tact and sagacity which was so remarkable in Newton." His earlier researches were connected with hydrodynamics, and the resisted motion of projectiles; in later years he was chiefly devoted to practical astronomy and geodesy. The portable repeating circle invented by him has had a very great reputation in France. He was one of the principal designers of the measurement of the French arc, and was employed in its superintendence, especially as regards the measurement of the base. His experiments on the pendulum were originally undertaken (I believe) in 1790, with a view to making it the basis of the national measures, but were afterwards subordinated to the greater scheme of terrestrial measurement. Baily records a fact connected with Borda, not unworthy of mention, as a caution to observers:—the *year* in which many of his experiments were made is not discoverable from the account of them, though the day, hour, minute, and *second*, are recorded with praiseworthy fidelity. From this time pendulum experiments assumed an astronomical and geodetical importance. The apparatus of Borda consisted of a slender metallic wire, attached at one end to a knife-edge suspension, and at the other to a small brass cap, nicely fitted by grinding to a sphere of platinum which formed the bob or weight of the pendulum. The oscillations were counted by the method of "coincidences," that is, by placing the experimental pendulum in front of a good clock with a known rate, and observing after how long a time the two pendulums (having started in the same direction) again coincided in their motions by one of them having gained or lost exactly two vibrations; a method which has been used at least since the time of Bouguer. The time of vibration being thus known, the distance from the knife edges to the bottom of the ball was measured by means of a scale; and due corrections for the position of the centre of oscillation were then applied.

(238.) Invariable pendulum.

By English observers, an invariable pendulum of the form of a flat bar, provided with a bob or weight, has usually been preferred, and on the whole it appears to be more satisfactory. Such a pendulum, after being compared with an astronomical clock at Greenwich, or any other place of reference, is taken to different stations and its rate of vibration determined, and it is then brought back and compared once more at the point of starting. Important series of observations of this kind have been made by Colonel Sabine and Captain Foster, and also by Admiral Duperrey.

(239.) Relative and absolute measures.

But the two individuals who have most studied the practical determination of the length of the seconds pendulum as a mechanical problem, are Kater

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Laplace and Mr Stokes on the earth's attraction.

[1] Clairaut (besides giving a theorem which, in the case of an ellipsoid, connects the polar compression with the increase of gravity there) showed that the increase of the force of gravity from the equator will vary as the square of the sine of the latitude. This he proved to be true when the spheroid is homogeneous, or when it is composed of similar concentric layers of varying density. Laplace confirmed the result by a different analysis, and farther showed, that if the earth be composed of concentric strata which are severally homogeneous, and nearly spherical, but otherwise arbitrary in form, and if the surface be that of a fluid in equilibrium (as it practically is when we refer the earth's figure to the sea-level), there exists a necessary connection between gravity and the superficial figure, which, in the case of an ellipsoid of revolution, leads to the same relation of the square of the sine of the latitude. In this case, also, the strata are presumed to be concentric. But in a recent and remarkable paper by Professor Stokes, it is shown that the law connecting the force of gravity and the figure of equilibrium still holds when no hypothesis whatever is made as to the distribution of the matter within the earth, provided always that it be consistent with the observed fact of the ellipsoidal figure of the earth's fluid covering. Thus the confirmation, by means of pendulum experiments, of Clairaut's Theorems cannot be regarded as a proof of the concentric arrangement of the strata, nor (so far) of the primitive fluidity of the earth. See *Cambridge Transactions*, vol. viii.; and for a simpler proof, *Cambridge and Dublin Math. Journal*, vol. iv. p. 194.

and Baily. As regards the determination of the Earth's figure, the *relative* length of a pendulum vibrating seconds in different latitudes is all that is required; but the *absolute* length in a given place is necessary for finding the force of gravity there expressed by the acceleration of falling bodies *in vacuo* in one second; and as the British standard yard was at that time made to depend on the length of the pendulum vibrating seconds at London, this enquiry was mixed up with the intricate one of National Standard Measures.

(240.) Captain Kater; his convertible pendulum. CAPTAIN HENRY KATER was a person of remarkable mechanical skill and ingenuity, and his numerous papers in the Philosophical Transactions, between 1813 and 1828, refer chiefly to the accurate construction and use of the Pendulum, the Balance, and certain Astronomical Instruments. He first applied to practical use the beautiful theorem of Huygens respecting the convertibility of the Centres of Oscillation and Suspension of the pendulum. A metallic bar pendulum was provided with two parallel knife-edges facing opposite ways, and upon either of which it might be swung. They were so arranged that when either was used as the point of suspension, the other nearly represented the centre of oscillation, and by means of a small adjustable weight, this condition might be accurately fulfilled; in which case (by Huygens' principle) the distance between the knife-edges corresponded accurately to the length of an equivalent simple pendulum. This elegant application was farther tested by Mr Baily, but it was found liable to serious practical objections. Baily dispensed with the sliding weight, and rendered the pendulum invariable: the distance of the knife-edges was adjusted by grinding.

(241.) His Collimator. To Kater we owe the invention of the floating Collimator, for ascertaining the accurate zero or level points of divided astronomical instruments. The optical principle on which it depends is a very beautiful one, and the invention of Kater, with several improvements in point of form, has become the auxiliary of nearly every observatory in the world. It is one of those small but happy improvements which affect materially the progress of Science.

(242.) Francis Baily; his early history and character. FRANCIS BAILY, who was born 28th April 1774, and who died 30th August 1844, was an instance of a person not endowed with extraordinary talents, yet of singular use in his generation. Those who knew Mr Baily personally, and what he accomplished for Astronomy, are best aware how rare and yet how estimable are such qualifications as his. Born of parents of a middle rank of life, educated at a country school, and at an early age thrown into the vortex of commercial life in the city of London, no probability could have appeared more remote than that he should acquire the respect of even the most accomplished Astronomers by his scientific acquirements and performances. He enjoyed the advantage, in the first place, of a perfectly sound and uninterrupted state of health until his 70th year. His intellect partook of the equable tone of his bodily powers. Method, and an ardour which, instead of acting by impulses, seemed inexhaustible and unvaried, were the secrets of his success. Mr Baily never was hurried, and he never was unemployed. He had always leisure to encourage men of like tastes, and he was never unwilling to learn from any one who had knowledge to communicate. To do one thing at a time was his first principle. When thoroughly accomplished, it was completely put aside, and a fresh subject undertaken. Whether an experiment or a calculation was found to require a month or three years, it was pursued to a successful completion, without stint or grudging. No amount of contrariety and failure in such matters was ever known to ruffle his temper, or to make his perseverance falter.

(243.) Founded the Astronomical Society. Francis Baily was known, in the first place, as the founder (in 1820) of the Astronomical Society of London, an institution of signal utility, which has ever since been conducted with great judgment and success. His accurate knowledge of past and current astronomical history, and his personal acquaintance with most European astronomers, enabled him to conduct its affairs with great advantage.

(244.) Writings on Eclipses, and Star Catalogues. Amongst his other acquirements, he studied history and chronology with his customary precision. A very able paper on the date of the celebrated Eclipse of Thales was his earliest scientific publication,[1] and the literature and phenomena of solar eclipses occupied his particular attention ever afterwards. His accounts of the Eclipse of 1820, of the Annular Eclipse of 1836, which he observed at Jedburgh, and the Total Eclipse of 1842, with its marvellous revelation of the rose-coloured protuberances of the solar atmosphere, are among the most interesting and classical of his writings. He promoted greatly the formation and publication of accurate Star Catalogues, and he invented, independently of Bessel, constant numbers for facilitating the calculation of Precession, Nutation, and Aberration, as affecting the places of particular stars. He also published a most useful collection of Astronomical Tables and Formulæ, and an elaborate and very curious life of Flamsteed.

(245.) I shall now proceed to notice his experiments on the Pendulum, which are more particularly connected with the present section.

(246.) Baily's pendulum observations. Mr Baily's most important observations were on a correction of the motion of a pendulum long misunderstood. The corrections usually admitted were the following:—1. For temperature altering the length of the pendulum. 2. For the height of the station above the level of the sea. Dr Young showed that this correction was commonly overrated, owing to the sensible amount of the attraction of the elevated land on which the experiment is made. 3. For the air's buoyancy. The mere resistance of the air to the motion of the pendulum may be shown to produce opposite and compensating effects in the descending and ascending semi-vibrations: but the presence of air, as of any other fluid, diminishes the total effect of gravity on the bob, and that in a degree depending on the density of the air or atmospheric pressure. But besides this obvious "reduction to a vacuum," it appears that the air acts also in a different way. Owing to its inertia and cohesion a portion of air is shoved along with the pendulum, or otherwise put in motion by it, and the force thus spent in moving air is not compensated during the two semi-vibrations. This effect was clearly ascertained and measured by Dubuat about 1786, and described in the second edition of his "Principes d'Hydraulique;" but it appears to have been totally unobserved by his own countrymen and others, who (like Borda) were soon after actively engaged with the same subject. The effect was experimentally re-discovered by Bessel, and made the subject of an admirable series of experiments by Baily, which were published in the Philosophical Transactions for 1832. He vibrated pendulums of different forms *in vacuo* and in air (as Colonel Sabine had done to a more limited extent shortly before), and he ascertained the corrected "reduction to a vacuum" to be in many instances double of the old correction, and to depend materially on the form and density of the pendulum. It even appeared that when a convertible pendulum is swung in two positions in the manner of Kater, the correction is different in the two cases, owing to the want of symmetry, so that a pendulum convertible in air of a given density is not convertible *in vacuo*, nor *vice versa*.

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[1] Phil. Trans. 1811.

Reduction to a vacuum.

(247.) Investigated by Bessel and others.

Bessel and Baily agree in imputing the effect to the clinging of a mass of air to the metallic pendulum, thus rendering it in effect a pendulum of much less density, for which the ordinary correction for buoyancy will have to be increased. This view is probably rather a popular than an exact expression of the fact, and the correction need not be always proportional to that of buoyancy. Poisson has treated the question mathematically, and Professor Stokes has recently resumed the whole subject, both mathematically and practically, and considers that he has arrived at precise mathematical results in several cases. The result may probably be a revival of interest in pendulum observations, which has manifestly very much declined since the existence of this irregularity has been fully established, and the incompetency of existing rules for "reduction to a vacuum" clearly shown.

Mr Stokes.

(248.) Result as to Earth's oblateness.

In 1833, Baily deduced from the very elaborate experiments of Captain Foster in both hemispheres $\frac{1}{289\cdot48}$ for the earth's compression. Colonel Sabine had found it $\frac{1}{288\cdot40}$ from his own observations. The French and Russian observers concur in obtaining a result sensibly greater. Of these experiments, Captain Foster's is by much the most extensive. Mr Baily's repetition of Cavendish's experiment for determining the earth's density, has been mentioned in a previous section.

The Cavendish experiment.

(249.) Recent geodetical measures: —Colonel Everest—M. Struve.

In conclusion of the subject of the figure of the earth deduced from observation I shall now briefly refer to the results of geodetical measures more recent than those noticed in the first section of this chapter, which comprehended the great French arc. In a matter so much of detail, which will be better appreciated from special articles in the *Encyclopædia*, I shall best fulfil the ends of this discourse, by merely directing attention to the two most conspicuous and important of these measurements of the earth, one in India, the other in central and northern Europe; the first directed by Colonel Everest, the second by M. Struve, the eminent astronomer of Pulkowa.

(250.) Lambton and Everest's Indian arc.

The measurement of an arc of the meridian in India by Colonel Lambton in the early part of this century, has been mentioned in a former part of this Dissertation, as well as in Sir John Leslie's. But its value has been prodigiously increased by the extension of the same by Colonel Everest, who was at one time the principal assistant and coadjutor of Colonel Lambton. The arc of Lambton, extending from Punnæ (Lat. 8° 9′ 35″) to Damargida (Lat. 18° 3′ 15″), was measured after the model of the English trigonometrical survey, by means of a 100-feet steel chain for the base, a 3-feet theodolite for the azimuths, and a 5-feet zenith sector for latitudes. Colonel Everest pursued the triangulation in a northerly direction for some years after the death of Lambton in 1823; but losing his health, and being forced to return to Europe, he was provided, by the princely munificence of the East India Company, with an entirely new set of instruments, and with two able assistants, Captains Waugh and Renny.

(251.) Difficulties under which it was executed.

He resumed operations in 1832, which were continued until 1840, and included an entirely new measurement of an arc extending from Damargida, where Lambton's arc terminated, to Kaliana (Lat. 29° 30′ 48″), a space of 797 miles, covering an arc of 11° 27′ 33″. The latest geodetical improvements were introduced. The bases were measured by General Colby's compensating bars, in which the effect of temperature is self-corrected. The signals from station to station were made during the day by heliotropes reflecting the solar ray parallel to the sides of the triangles to be measured. The azimuths were determined by a 3-feet theodolite of Troughton, in addition to that of Carey used by Lambton; the astronomical observations were made with two circles of large dimensions. The difficulties and annoyances experienced in conducting so vast a work, requiring such excessive accuracy, in so remote a situation, can only be judged of by referring to Colonel Everest's graphic details contained in his elaborate account of it, published at the East India Company's expense in 1847. The heats and the rains, the dull opake atmosphere of the Doab, with its boundless and densely-wooded flats, the jungle fever and the wild animals, were natural impediments enough. But Colonel Everest, whose conscientious anxiety reached almost a nervous pitch, seems not to have been satisfied with any one instrument which the mechanicians of London could produce ; but to have metamorphosed most of them, partly with his own hands, partly by native aid. It says much for his ability in this respect, that the results appear entitled to compete with all the most exquisite of the kind in Europe. His bases, for instance, about 7½ miles in length, when checked by intermediate triangulation above 400 miles in extent, differed in one instance by 4, in another by 7 inches from the primary measurement. The whole extent of Lambton's and Colonel Everest's operations includes a continuous arc of 21° 21′ (1477 miles), by far the greatest at that time executed.

(252.) Russian arc by M. Struve.

It is indeed only rivalled in this respect by a vast operation very lately executed in Russia and other northern countries of Europe, by which an arc of 25° 20′, extending from the banks of the Danube to the shores of the Arctic Sea, near the North Cape, has been measured under the general superintendence and direction of that able astronomer M. Struve, whose meritorious labours in other departments of astronomy will be specified in a succeeding section. The results are still incomplete, though the operations in the field were happily concluded just in time to prevent their total frustration by the unhappy war in which Russia has since engaged.

(253.) Its extent.

The arcs of India and of Russia include a space from Lat. 8° to Lat. 71°, with the exception of only about sixteen degrees, and are unquestionably the most important which exist for the determination of the earth's figure. When to them we add the French arc of 12° 22′ in a medium latitude, it will scarcely be necessary to take into account any other, at least for the Northern Hemisphere.

(254.) The following brief details of the Russian arc are taken from the provisional report of M. Struve (1852).

(255.) Details of the Russo-Scandinavian Arc.

The southern extremity of the Russo-Scandinavian arc is Ismaïl on the Danube (Lat. 45° 20′), the northern extremity is Fuglenaes on the island of Qualoe in Finnmarken (Lat. 70° 40′). The interval from Torneå to Fuglenaes (4° 49′) was measured by Swedish and Norwegian engineers; all the remainder by those of Russia, and, in particular, by M. Von Tenner, who, with M. Struve, has since 1816 directed the whole operation. The whole line is remarkably free from considerable inequalities of ground, and from mountain ranges, so that local attractions are probably inconsiderable.[1] On the other hand, extensive forests extending over dead flats have, in the southern part of the arc (as in India), occasioned great difficulties, and compelled the erection of numerous temporary structures to overlook the country. In the north the extraordinary refractions have, as usual, created some difficulties. Ten different base lines, all at a small height above the sea, form part of the operations. It is a very satisfactory circumstance, that by the care of M. Struve and Mr Airy, the standards of length used in the Indian and Russian arcs have been directly compared.

(256.) General result as to the Earth's ellipticity from geodesy;

The calculation of the figure of the earth from the completed Russian arc, in combination with others, has not yet been made, but it is believed that it will indicate an ellipticity somewhat greater than that generally received. The results obtained by Colonel Everest, on the other hand, by comparing his arc with those of Europe, give generally small ellipticities, that is under $\frac{1}{300}$. The French and Indian arcs, for instance, give $\frac{1}{316}$. Now Mr Airy had deduced 20 years ago from the best existing observations $\frac{1}{298}$; Bessel, a few years later, obtained the almost identical result of $\frac{1}{299}$; and Schmidt of $\frac{1}{301}$.

and from pendulum experiments.

The determinations by means of the pendulum are somewhat larger. The extensive observations of Colonel Sabine and Captain Foster concur in giving an ellipticity of $\frac{1}{289}$; but the French experiments by Duperrey and Freycinet lead to a result considerably greater. The discrepancy between the geodetical and pendulum results may of course be a real one depending on local variations of density. The astronomical determination from the lunar inequalities, which might be expected to concur with the results of the pendulum, gives (as we have seen in the chapter on Physical Astronomy, Art. 63) $\frac{1}{305}$ at a mean.

(257.) British arc of parallel.

I regret that my limits do not permit me to speak of the measure of degrees of longitude or arcs of parallel, as another test of the earth's figure. The results, however, cannot compete in point of certainty with those from arcs of the meridian. It may be satisfactory to add, that the British arc of parallel from Greenwich to Valentia (west coast of Ireland) sensibly accords with the earth's figure obtained independently.

(258.) M. Foucault's pendulum experiment,

In connection with the subject of the pendulum treated in the earlier part of this section, I shall here mention a very remarkable experimental observation communicated to the Paris Academy of Sciences, on the 3d February 1851, by M. Léon Foucault, to whom we also owe some ingenious experiments on the velocity of light. It is not indeed connected with the determination of the earth's figure, but it has a connection with astronomy, inasmuch as it affords the most remarkable and direct proof of the earth's rotation round its axis.

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[1] In India, on the contrary, the local attractions of the Himalaya must be very sensible ; indeed Mr Pratt has calculated them to be so considerable, as to have given rise to a curious speculation by Mr Airy as to the circumstances which may tend to diminish the attraction of mountain ranges.—(*Phil. Trans.* 1855.)

(259.) demonstrating the Earth's rotation.

Suppose a considerable weight suspended by a wire of regular elasticity from a fixed point or stand connected firmly with the ground; and let us first imagine the place of the experiment to be exactly over the North Pole. Let the wire pendulum be swung so as to coincide with the plane of the meridian of London. As the earth rotates, the wire and the ball must evidently rotate too. But the *motion* of the mass originally impressed parallel to a given plane will continue in that plane, and consequently the plane of motion will coincide in the course of 12 hours with every meridian in succession, and the apparent rotation will be entirely completed in a uniform manner in 24 hours. In any other latitude than 90°, but greater than 0°, a continuous and regular apparent change of motion must also occur, since a meridian of the globe does not preserve its parallelism during diurnal motion, excepting only at the equator; consequently, at all points of the earth's surface, except at the equator, the plane of motion of the pendulum will vary uniformly in azimuth—quicker, however, in high than in low latitudes. To find this velocity, it is only necessary to decompose the rotation of the earth round its axis into two, one of which (which is alone effective) is round the vertical of the place of observation. The apparent angular motion is thus proportional to the sine of the angle of latitude. Thus, in an hour, it is 15° × sine lat.

(260.) Corrections to be attended to.

M. Foucault's experiment was made, in the first instance, with a pendulum of steel wire from ·03 to ·05 inch in diameter, bearing a ball of 12 pounds weight. It is desirable to make the pendulum vibrate in small arcs, in consequence of the tendency to ellipticity in the vibrations, which is necessarily accompanied by a rotation of the major axis of the ellipse, which might easily be mistaken for the influence of the earth's motion. To take account of this disturbing force, we have only to measure accurately the greater and less axes of the ellipse described. Then a revolution of the apsides (from this cause only) will be performed in a time which will be found by multiplying the time of a *double* vibration of the pendulum *by 8 times the square of the length of the pendulum, divided by 3 times the product of the two axes of the ellipse.* This formula is due to Mr Airy. The theory of M. Foucault's beautiful experiment has been verified by numerous experiments in different latitudes.

(261.) Its theory investigated by M. Hansen.

Very recently the theory of the motion of a pendulum suspended by a thread or wire has been considered in the most general manner by M. Hansen, the physical astronomer, with reference to the earth's motion.[1] It is an intricate problem of analytical mechanics. But the results show, as might have been anticipated, that all the *sensible* results are those which the geometrical treatment of the question indicate.

§ 5. M. ENCKE. *Cometary Astronomy—Periodic Comets of Halley and Encke.* GAMBART'S *and* Biela's *Comet—Comets of* 1811 *and* 1843. Mr HIND—*New Planets or Asteroids.* Mr LASSELL—*Newly discovered Satellites.* Mr Bond.

(262.) Professor Encke. Periodic Comets.

PROFESSOR JOHANN FRANZ ENCKE, Director of the Observatory of Berlin, is one of the most eminent physical and practical astronomers of the present day. The author of many valuable observations and important memoirs, he is best known by those which are connected with the motions and theory of Comets. I shall therefore devote this section to an abstract of the progress of this interesting subject, and more particularly of M. Encke's discoveries and speculations. I must premise, however, that, easy and agreeable as it would be to introduce here a detailed essay on Cometary Astronomy, the design and extent of this discourse alike forbid it, and at the cost of some self-denial, I will endeavour to confine myself entirely to what is most new and characteristic in the Cometary history of later years.

(263.) Halley's Comet—period 76 years.

Halley's Comet.—Before proceeding to describe the remarkable comet especially connected with the name of ENCKE, it will be proper to resume the history of Halley's Comet where it has been left off by Sir John Leslie in his Dissertation. That Comet—the comet of 1682—must ever remain memorable, perhaps the most so of its class, as being the first whose return was confidently predicted, in firm reliance on the Newtonian Theory of Gravity. Halley's announcement—grounded not on vague analogies, but on laborious computations—that it would reappear early in 1759, was realized almost to the letter; and Clairaut, whose surprising analytical ability often left but little to his successors to accomplish, calculated the perturbations with an accuracy which even the present state of physical astronomy has hardly exceeded. Indeed no *general* method for calculating perturbations in highly elliptic orbits is as yet in use, and though the methods of Clairaut have been superseded by those of Lagrange and Bessel and Leverrier, the summation of the effects by the method of "quadratures" is always used,—the periodic time of the comet being divided into short intervals throughout which the elements are considered invariable, and during which the configurations and perturbing effects of the principal planets are computed with much labour.

Its return in 1759.

(264.)

The chief improvement in the calculation of perturbations is the introduction by Lagrange of the celebrated method of the Variation of the elements (44.)

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[1] Theorie der Pendelbewegung. Dantzig, 1853.

Its perturbations calculated by various astronomers.

His successors have distinguished themselves chiefly by the praiseworthy minuteness and extent of their calculations, which are amongst the most laborious, if not indeed the most laborious, which occur in Physical Astronomy. The computers who calculated the return of Halley's Comet in 1835 were four in number, MM. Damoiseau, Pontecoulant, Lehmann, and Rosenberger. Their memoirs are all considered by competent judges to be excellent, but especially that of Rosenberger, who calculated more fully than the others the perturbations from 1682 to 1759, and who has introduced a theoretical correction of some importance. Some idea of the extent of these calculations may be formed from the fact, that in some parts of the orbit the Elements were made to vary for intervals of only two days. The Comet of Halley was rediscovered at Rome on the 6th August 1835, in the Jesuits' College. The error of Rosenberger's Ephemeris was only *seven minutes of arc*, and the perihelion passage took place on the 16th November (civil reckoning), five days *after* the predicted time. Bessel states the remarkable fact, that the coincidence of the comet's path with the results of previous calculation is as close as the use of five-place logarithms in computing the perturbations would permit. All this is very creditable to the state of Astronomy; still it is infinitely less remarkable than Clairaut's approximation, only a little less close, made 77 years before. It is a matter of regret that neither in the matter of this comet, nor in any other point of theory connected with Cometary movements, have our countrymen made any considerable advance since the time of Halley.

(265.) Its return in 1835.

At its return in 1835, this Comet was watched until May 1836, and in the course of its long visibility was made the subject of minute and admirable telescopic researches, by Bessel in Europe, and by Sir John Herschel at the Cape of Good Hope. Their observations strictly confirmed a remark of M. Valz, that the Tails of Comets, though evidently generated under the influence of the neighbourhood of the Sun, yet commonly disappear at the period of closest approach. This, at least, was the case with Halley's Comet. The tail began to grow on the 2d October, two months after its discovery, and diminished after the 15th (a month before perihelion). The comet reappeared in the end of January without any vestige of a tail, and then dilated in absolute bulk with incredible quickness. But before its final disappearance, on the 5th May, the tail is supposed to have been reabsorbed into the nucleus, which presented then a uniform circular outline. The evolution of the highly-expansible luminous matter of the tail took place from the nucleus in luminous fan-like jets, directed on the whole *towards* the Sun, and issuing on the side of the Comet exposed to that body. The jets had a vibratory motion. The tail (directed *from* the Sun) was formed by the abrupt inflexion of these effluent jets, in a manner resembling electrical repulsion; and Sir John Herschel has not hesitated to ascribe the phenomenon to the combination of a repulsive force as respects the Sun, ("of an energy very far exceeding the gravitating force towards that luminary") with "a peculiar and highly energetic attraction to the nucleus, differing from, and exceptional to, the ordinary power of gravitation."[1] The opinion that polar forces resembling magnetism or electricity are necessary to explain the phenomena of Comets, has been for some time current in Germany, and received, I believe, the countenance of Bessel. That there exist in the movements of these bodies anomalies so great as to render the sufficiency and completeness of the Theory of Gravity suspected by such high authorities, makes the statement of them very important, though I confess a great reluctance to share in the conclusion.

Its peculiar features.

(266.) Table of its returns.

I shall terminate this notice of Halley's Comet with a table of the dates of its probable perihelion passages, according to M. Laugier and Mr Hind.[2] The earlier appearances are deduced from the Chinese Annals:—

Date.	Interval. Years.	Date.	Interval. Years.
B. C. 11·80			
	77·87		77·45
A.D. 66·07		A. D. 989·70	
	75·17		76·55
141·24		1066·25	
	77·02		79·05
218·26		1145·30	
	76·99		78·22
295·25		1223·52	
	78·59		78·29
373·84		1301·81	
	77·66		77·04
451·50		1378·85	
	79·34		77·59
530·84		1456·44	
	77·96		75·21
608·80		1531·65 (o. s.)	
	76·00		76·14
684·80		1607·82 (n. s.)	
	75·64		74·88
760·44		1682·70	
	76·82		76·49
837·26		1759·19	
	74·99		76·68
912·25		1835·87	

The differences in the above periods are attributed to the effects of perturbation. The extreme distance of the Comet's path from the Sun is 35⅓ times the radius of the Earth's orbit, which is only one-sixth part greater than the distance of Neptune, and therefore nearly within the recognized limits of the planetary system.

(267.) Comet of Encke.

Comet of Encke.—Next in interest to the Comet of Halley is that discovered by Pons of Marseilles in November 1819, which was first suspected, then proved by Professor Encke, to revolve in an elliptic orbit of short period (considerably interior, in fact, to the orbit of Jupiter), and made the subject by him of a series of investigations altogether peculiar. On this account it bears the name of Encke, instead of that of its discoverer Pons, although M. Encke himself, with unaffected modesty, always describes it as the Comet of Pons.

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[1] See Sir John Herschel's *Outlines of Astronomy*, and *Results of Observations at the Cape of Good Hope*.

[2] Taken from Mr Hind's small work on Comets.

(268.) Cometary orbits derived from observation.

Newton gave, in the *Principia*, his celebrated solution of the problem of determining a Comet's orbit assumed to be parabolic, from three geocentric places. This solution has been simplified and improved by Lagrange and Boscovich, and also by Olbers. Laplace gave a method for an elliptic orbit, which may represent any number of observations. Gauss, in his *Theoria Motûs Corporum Celestium*, treated the subject with great skill and generality. I am unable to state who first attempted to discriminate an elliptic from a parabolic cometary orbit, or to determine the period in the former from observations at one apparition only. It is evident that such outstanding differences as are irreconcilable with a parabolic orbit, will be most perceptible in the case of comets whose orbits have a tolerably short major axis, or whose period is not very great, and will be materially increased by watching a comet through a considerable part of its orbit, which the assiduous application of telescopes to every part of the heavens has of late years rendered much more frequent than formerly. Amongst others, Bessel, who has signalized himself by a capital performance in this, as in every other department of Astronomy, applied rigorous methods to determine the orbits of the comets of 1807 and 1815; the latter of which will very probably return to its perihelion in 1887. It is undeniable, however, that expert calculators have often been deceived in assigning orbits, even when believed to be of short period, founded upon a single apparition.

(269.) M. Encke's researches on the comet of 1819—period $3\frac{1}{4}$ years.

M. Encke, however, was more fortunate in the case of the first comet of 1819. Using the methods of Gauss, he showed that an Elliptic Orbit of about $3\frac{1}{4}$ years must be admitted, and that the comet had probably been already observed in 1786, by Méchain, in 1795 by Miss Herschel,[1] and in 1805 by Pons. He investigated with great labour the effects of the planetary perturbations on this body, which, in the case of Jupiter, are occasionally very large, if that planet be in the part of its orbit near the aphelion position of the comet, when it approaches the orbit of Jupiter. The careful calculations of M. Encke for the next return in 1822 were verified by the observations of Sir Thomas Brisbane, at that time fortunately governor of New South Wales, where he had, with characteristic liberality, founded an Observatory. Since then, this body, insignificant in its physical appearance (being to all appearance a small cloud of vapour without a solid nucleus), has been detected in one or another part of the world *at every revolution*:—namely, in 1825, 1828, 1832, 1835, 1838, 1842, 1845, 1848, and 1852; so that the Comet has been observed at fourteen (not all consecutive) returns.

Its apparitions.

(270.) Its accelerated motion

The complete establishment of the existence and periodicity of a comet, quite in the interior of the planetary system (its greatest distance from the Sun being four times the Earth's distance, and its least distance but one-third of the Earth's), was a discovery in itself highly interesting. But something yet remained behind. Professor Encke, in comparing the earlier with the later apparitions of the Comet, detected a gradual acceleration of its movement, which amounted between 1786 and 1838, to 1·8 days, on a period of about 1211 days; being about $2\frac{1}{2}$ *hours* per revolution. Whatever may be the cause of this, the *fact* is undisputed, even by Bessel, who was indisposed to accept M. Encke's explanation. This fact, it will be observed, is *unique* in Astronomy. The major axis and periodic times of the planets and satellites have, as we have seen in the chapter on Physical Astronomy, no secular variation. The moon's apparent acceleration has been otherwise accounted for. M. Encke at once, and at an early period, attributed the acceleration of the Comet's mean motion to the effect of a slightly resisting medium, insensible in the case of the planets, partly owing to their incomparably greater density (for this Comet appears to be one of the most loosely aggregated bodies known, being transparent to its very centre); and also, to the circumstance, that the density of the ether or resisting medium is assumed to diminish rapidly at a distance from the Sun. M. Encke supposes it to decrease in density with the square of the distance, and only to affect the Comet sensibly within 25 days preceding or following its perihelion. That the effect of resistance is to accelerate the return of the Comet is evident, by considering that the projectile force becoming gradually extinguished, the Sun's attraction must be more available to pull the body inwards at each revolution, thus shortening the major axis of the ellipse, and diminishing the time.

attributed to a resisting medium.

(271.) Perturbations of Encke's comet applied to rectify the masses of Mercury and Jupiter.

In order satisfactorily to arrive at any such conclusion, it was of course necessary to estimate with great accuracy the perturbing effects of the planets on the Comet's motion; and it is not a little curious and satisfactory, that the movements of this insignificant erratic body should have occasioned a material rectification of the masses of two of the Planets. M. Encke very early suspected that the received mass of Jupiter was too small, a fact clearly established afterwards by Mr Airy; and in 1838 M. Encke showed that the mass of Mercury (which, not having a satellite, was little more than guessed at previously) had been assumed nearly *three times* too great by Lagrange. The perihelion of the Comet approaches much

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Miss Caroline Herschel.

[1] Caroline Lucretia Herschel, sister of Sir William and aunt of Sir John Herschel, deserves a passing notice, not only as the independent discoverer of *eight* comets (of which five were first seen by her), but as the indefatigable and intelligent assistant of Sir William Herschel during the busiest years of his life. For this service King George III., carrying out his judicious liberality to her brother, granted her a small pension. She died at Hanover 9th January 1848, aged 97.

more nearly to the orbit of Mercury than the aphelion does to that of Jupiter; consequently at times the perturbations due to the former planet may be very great, and though the gravitating mass of the Comet is utterly unknown, yet since the momentary direction of its motion depends solely on the *ratio* of the attractive force of the Sun and Mercury, its observed course gives the means of estimating that ratio.[1]

(272.) Theory of a resisting medium not altogether favourably received, The theory of a resisting medium was, on the whole, well received, especially in England, where some of our first authorities gave it their adhesion. The then recent establishment of the Undulatory Theory of Light, was thought by many to receive a confirmation from this evidence of something material filling the planetary spaces. In Germany the hypothesis of resistance received the complete opposition of Bessel's high authority; who declared that "a hundred other reasons" might be found for the fact of the acceleration, *which he admits to be true.* Encke, in reply, reduces these 100 possible hypotheses to *four*, of which we shall mention only one, as seemingly important, namely, the forces exerted with so much intensity within the body of the Comet itself, as indicated by the projection of the tail. But he observes, with great sagacity, that these forces, being apparently usually excited in the line of the radius-vector joining the Comet and the Sun, can hardly be supposed to affect the periodic time. It having also been objected that Halley's Comet shows no trace of acceleration, but, if anything, of the reverse, M. Encke truly says, that its perihelion distance does not lie within the assumed limits of the denser ether.

(273.) and still questioned. Nevertheless, the theory of a resisting medium in space is not perhaps very popular, except in England. Although M. de Humboldt appears to favour it, I understand that the German astronomers in general scarcely regard it as in any degree proved.

(274.) Yet, if not true, the cardinal fact remains unexplained. The anomalous phenomena of the Tails of Comets, considered by Herschel to be altogether inexplicable by the law of gravity, demand the closest scrutiny; and one can hardly help supposing that the two difficulties may be in close connection. As the Newtonian law is now considered (since the discovery of Neptune, and the latest corrections of the Lunar Tables) to be *absolutely sufficient* to account for everything connected with planetary motion, the Astronomy of Comets will be looked to with increasing interest, as likely to reveal some laws of nature not otherwise to be detected. In this respect, Professor Encke's labours are likely to be more and more important in their results.

(275.) M. Encke on perturbations. With reference to this very eminent astronomer, we have only to add, that he has for a great many years been at the head of the Observatory at Berlin, and in that capacity has published an Astronomical Ephemeris of first-rate excellence. It is as a physical astronomer, however, that he will be principally remembered. Besides his admirable investigations connected with the Comet, he improved the theory of Vesta, and has very lately published a new Method of Computing Perturbations, especially for orbits considerably elliptical. Neptune was discovered at his Observatory, by the assistant astronomer, M. Galle.

(276.) Gambart's and Brela's comet. *Gambart's and Biela's Comet.*—Jean Gambart, one of the most promising astronomers in France, died of consumption at a comparatively early age, I believe in 1836. He was director of the Observatory at Marseilles, which, notwithstanding its very unfavourable position in the midst of the town, has acquired considerable celebrity as regards the discovery and observation of Comets. Pons, by whom Encke's Comet was found, both in 1805 and 1818, conducted the Observatory; but its mounting was as bad as its situation, and Pons used despairingly to describe his telescope as rather *paralytic* than *parallactic.* To this crippled establishment M. Gambart succeeded, and by his skill in managing his defective instruments, and by his patience in sweeping for Comets, he discovered and subsequently computed the orbits of a number of these bodies between 1822 and the period of his death. Gambart was highly esteemed, both by French and foreign Astronomers. Pons also deserves great credit for his extraordinary diligence in the discovery of Comets, and M. Valz, who still directs the Observatory of Marseilles has cultivated this and other branches of the science with success.

(277.) Periodicity in 6$\frac{3}{4}$ years. Gambart's most remarkable discovery was the periodicity of the first Comet of 1826, having detected that body independently at Marseilles, though it had been observed some days previously in Bohemia, by Biela, an officer in the Austrian service. It is most usually called Biela's Comet, though it might with equal right be termed Gambart's, who assigned its path and predicted its return. Clausen, about the same time with Gambart, assigned it a period of about 7 years; and it was identified with former appearances in 1772 and 1805–6. Its period thus appeared to be 2460 days, or 6$\frac{3}{4}$ years; its aphelion is a little exterior to Jupiter's orbit, and its perihelion is not much within the Earth's. This Comet's orbit very nearly intersects in one place the orbit of the Earth, so that had the earth been one month forwarder in its annual course in 1832, a collision would have taken place, or at least the Earth would have been enveloped in a cometary haze; for it is difficult to imagine a *collision* with a body whose tenuity is so excessive, that Sir John Herschel perceived through its entire thickness (estimated at 50,000 miles) stars of the most excessive minuteness (16th or 17th magnitude) as seen by his 20-feet reflector. It is an interesting circumstance, that the first predicted perihelion passage, in 1832, took place within *some hours* of the time fixed by MM. Santini and Damoiseau, though the perturbations of Jupiter were, as usual, large.

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[1] On the Masses and Densities of the Planets, see Encke in *Astron. Nachrichten*, vol. xix., col. 187.

(278.) Biela's Comet has been since recognised in 1846 and 1852, but it was not seen in 1839. It does not appear to be admitted that it shows any acceleration due to a resisting medium. Its perihelion distance is, however, considerable.

(279.) Division of the body of the comet in 1846.

At the apparition of 1846 an extraordinary circumstance occurred. When discovered in the end of November 1845 it appeared round and single. On the 19th December it was observed by Mr Hind to be elongated, and ten days later was seen in America (and soon after at Cambridge and elsewhere) to have divided into two seemingly distinct nebulous parts.[1] These continued to subsist and move independently throughout the remainder of the apparition: the real distance of the centres being about 150,000 English miles. In 1852 the comet was rediscovered at Rome; the division into two still subsisting, but the interval of separation being increased about eight-fold.

(280.) Other periodical comets.

Besides the comets of Encke and Biela, there are several others which are suspected on good grounds to have periods of from 5½ to 7½ years, their aphelia all lying in tolerable proximity to the orbit of Jupiter. But among these the return of only one has yet been verified by observation; namely, the comet of Faye, which, after passing its perihelion 17th October 1843, returned to it 3d April 1851, within an hour of the time predicted by M. Leverrier. The motion of comets of short period seems to be invariably *direct* or conformable to that of the planets. The inclination of their orbits to the Ecliptic is usually moderate.

(281.) Great comets of 1811 and 1843.

Great Comets of 1811 *and* 1843.—The finest comets of the last hundred years were those of 1811 and 1843. The former was observed for a length of time altogether unusual, having been visible from March 1811 to August 1812. There is pretty good reason to think that its period is not much less than 3000 years. The comet of 1843 was even more splendid, but its flight was more rapid, and it was not favourably seen in northern latitudes. It was visible at many places in broad daylight when less than 4° from the Sun, and at one time a tail 65° in length could be traced. The circumstance which distinguishes this comet from all others which have been computed is the smallness of its perihelion distance, which was only $\frac{1}{200}$ of the radius of the Earth's orbit, or the comet approached the Sun's body within *one-seventh* of his radius. The solar disk then subtended an angle at the comet of 121½°, or the glare was equal to that of 47,000 suns as seen by us! The heat to which the comet was exposed is supposed to have exceeded 24 times that concentrated by our most powerful burning-glasses by which even rock crystal has been fused.[2]

(282.) Discovery of new Planets or Asteroids.

Mr Hind.—*Discovery of New Planets.*—We have spoken in a former section (161), of the discovery of four small planets or asteroids between the orbits of Mars and Jupiter. They were found between the years 1801 and 1807. An interval of nearly forty years elapsed without any addition to the members of our system. In 1845 a new asteroid, Astræa, was found by M. Hencke; the following year was distinguished by the discovery of Neptune under unparalleled circumstances; and since 1847 every year, down to the present time (1855), has added to our knowledge of the group of asteroids.

(283.) Mr Hind.

Among the discoverers of these planetary bodies Mr Hind has been distinguished by frequent success, under circumstances which appeared by no means peculiarly advantageous. This indefatigable observer and computer commenced (I believe) his astronomical career as one of the assistants at Greenwich, and afterwards had the sole charge of the private observatory of Mr Bishop, a wealthy citizen of London, together with the use of a fine refractor equatoreally mounted. It is within the Regent's Park, close to the smoke of the metropolis, that Mr Hind has discovered a larger number of planetary bodies than any other person living. Next to him M. de Gasparis of Naples has been most successful. Unquestionably the impulse towards these new discoveries has been given by the indefatigable industry of astronomers (principally those of Germany), in constructing minutely accurate star-maps. Mr Hind is also advantageously known by the discovery of several comets, and by his ingenious observations in sidereal astronomy, especially on variable stars. I shall here give a table of the asteroids in the order of discovery as at present known (July 1855).

M. de Gasparis.

List of the Asteroids.

1	Ceres	1801	Jan. 1	Piazzi.
2	Pallas	1802	March 28	Olbers.
3	Juno	1804	Sept. 1	Harding.
4	Vesta	1807	March 29	Olbers.
5	Astræa	1845	Dec. 8	Hencke.
6	Hebe	1847	July 1	Hencke.
7	Iris		Aug. 13	Hind.
8	Flora		Oct. 18	Hind.
9	Metis	1848	April 26	Graham.
10	Hygeia	1849	April 12	De Gasparis.
11	Parthenope	1850	May 11	De Gasparis.
12	Victoria		Sept. 13	Hind.
13	Egeria		Nov. 2	De Gasparis.
14	Irene	1851	May 19	Hind.
15	Eunomia		July 29	De Gasparis.
16	Psyche	1852	March 17	De Gasparis.
17	Thetis		April 17	Luther.
18	Melpomene		June 24	Hind.
19	Fortuna		Aug. 22	Hind.

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[1] A similar phenomenon is related by Seneca. See Grant's *History of Astronomy*, p. 302.

[2] See many other interesting particulars of this comet in Sir J. Herschel's *Outlines of Astronomy*, arts. 589, &c. See also interesting details on the subject of comets generally in Mr Hind's and Mr Milne's works on comets, and in Mr Grant's excellent *History of Physical Astronomy*.

20 Massilia	1852	Sept. 19	De Gasparis.
21 Lutetia		Nov. 15	Goldschmidt.
22 Calliope		Nov. 16	Hind.
23 Thalia		Dec. 15	Hind.
24 Themis	1853	April 5	De Gasparis.
25 Phocæa		April 6	Chacornac.
26 Proserpine		May 5	Luther.
27 Euterpe		Nov. 8	Hind.
28 Bellona	1854	March 1	Luther.
29 Amphitrite		March 1	Marth.
30 Urania		July 22	Hind.
31 Euphrosyne		Sept. 1	Ferguson.
32 Pomona		Oct. 26	Goldschmidt.
33 Polyhymnia		Oct. 28	Chacornac.
34 Circe	1855	April 6	Chacornac.
35 Leucothæa		April 19	Luther.

(284.) New Secondary Planets. Mr Lassell.

Mr Lassell.—*New Secondary Planets.*—Mr Lassell of Liverpool deserves a more lengthened notice than our limits will permit, not only as a distinguished discoverer, but as one whose success cannot be too widely made known as an encouragement to others. This gentleman, engaged in mercantile pursuits in an eminently commercial town, possessing little leisure and no enormous fortune, has contrived, in the intervals of business, to construct with his own hands telescopes which in accuracy of definition appear to rival any which art stimulated by national liberality has yet constructed elsewhere, and to use them with a degree of skill and success which has not been exceeded (nor in some respects equalled) by any astronomer whether professional or otherwise. I speak, let it be observed, of accuracy of definition, such as is necessary to display minute points of light, like the satellites of Uranus. In respect of the amount of *illumination* requisite for the display of many diffuse faint objects among the nebulæ, the gigantic telescopes of Herschel and Lord Rosse are of course superior.

(285.) His instruments.

Mr Lassel's observatory near Liverpool was erected in 1840. The principal instrument is a reflecting telescope of 24 inches aperture (completed, however, only some years later), mounted equatoreally, an arrangement requiring great mechanical skill, but, as the results show, most effectually accomplished. The speculum was worked and polished by machinery constructed by Mr Nasmyth, but principally devised by Mr Lassell, after he had examined and tried Lord Rosse's method. I should think it must be admitted to be the most perfect optical work of its kind ever made: for I believe there is no test object in existence which Mr Lassell has not seen with it; in fact he has discovered the most delicate tests himself,—the 6th star of the group θ Orionis (though not *first* seen by him), a satellite of Neptune, an eighth satellite of Saturn, and several satellites of Uranus.

(286.) He discovers a satellite of Neptune,

Not many days had elapsed after the discovery of Neptune, before Mr Lassell, directing his telescope to it, perceived a satellite (as he believed) on Oct. 10, 1846. The discovery was fully made out in the following year, and was soon after verified by the great refractors of Pulkowa and Western Cambridge (U.S.) Its period is about 5·879 days,[1] and its discovery was of singular importance as leading to a knowledge of the mass of the planet.

(287.) and one of Saturn.

Till 1848 only seven satellites of Saturn were admitted. The two closest to the planet were detected by Sir William Herschel in 1789, and have been seen by *very* few astronomers since. During five years' residence at the Cape, Sir John Herschel never but once obtained even a doubtful glimpse of the closest with an 18-inch mirror. The third, fourth, and fifth were discovered by Cassini in 1684; the sixth and most conspicuous by Huygens in 1654: the outermost by Cassini in 1671. To these an *eighth* satellite, intermediate in position between the two last, was added by Mr Lassell on the 19th September 1848. By a singular coincidence, it was recognised as a satellite *the very same evening* by Mr Bond of Cambridge (in America) with the great Munich refractor. The new body was called Hyperion, in conformity with Sir John Herschel's suggestion of distinguishing the satellites as well as the planets by mythological names. On the 22d November 1850 Mr Lassell saw at once Saturn with his whole train of eight satellites—a glorious spectacle probably enjoyed by no other astronomer. In the same month of November Mr Bond discovered a faint or dusky ring of Saturn interior to the two long known. It is probably nebulous, for by Mr Lassell's observations and Mr Jacob's it appears to be transparent.

Faint ring of Saturn discovered by Mr Bond.

(288.) Satellites of Uranus.

Sir William Herschel thought that he recognised six satellites of Uranus. The second and fourth of his table have been observed by several astronomers, particularly Sir John Herschel and M. Lamont. Their periods are $8^d\ 17^h$ and $13^d\ 11^h$. To these Mr Lassell, aided by the fine climate of Malta (to which for two seasons he removed his telescope), has conclusively added two more: one, appearing to coincide with the closest of Herschel's, of which the period is $4^d\ 3^h\ 28^m$, and one still nearer the planet revolving in $2^d\ 12^m\ 29^s$, the shortest orbital revolution in the solar system. Mr Lassell doubts seriously the existence of any other satellite.[2]

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[1] From Mr Lassell's observations at Malta, 1852–3.

[2] See *Astron. Society's Notices*, xiii. 151; and xiv. 133.

§ 6. *Sidereal Astronomy since* 1820.—M. Struve—*Double Stars. Observatories of Dorpat and Pulkowa.* Sir John Herschel—*Orbits of Double Stars. Magnitudes of Stars. Variable Stars.* Earl of Rosse—*His Telescopes. Nebulæ.* Henderson and Bessel—*Parallax of Stars.*

(289.) Continuation of the history of Sidereal Astronomy.

As it is absolutely necessary to bring this chapter to a speedy close, and as I have already anticipated, in the account of Sir William Herschel's discoveries, part of what relates to the recent history of the Astronomy of the Fixed Stars, particularly the "Constitution of the Heavens," and the motion of our system in space, I shall condense within brief compass a few leading facts connected, in the *first* place, with the Orbits of Double Stars, the Brightness of Stars, and the constitution of Nebulæ, and these subjects I shall connect with the names of the elder M. Struve, Sir John Herschel, and Lord Rosse; the *second* topic shall be the Parallax and distance of the fixed stars, as ascertained more particularly by the late professors Henderson and Bessel.

(290.) M. Struve.

Friedrich Georg Wilhelm Struve has been the most assiduous observer of double stars since the time of Sir William Herschel. No discovery in this department can for a moment compete with the great one of the orbital revolution of one star round another. But M. Struve, by devoting his chief energies during the most active years of his life, since 1813, to the assiduous continuation of Herschel's observations, has added immensely to our knowledge of these systems, and has earned the reputation of one of the most skilful of modern practical astronomers. His most elaborate observations were made at the Russian Observatory at Dorpat, with a noble refractor by Fraunhofer, nearly 10 inches aperture, and 13½ feet in focal length. He has published three works on the subject of double stars, one in 1824, one in 1837, and one in 1852, besides minor papers. The second of these works contains the particulars of about 3000 double stars, deduced from a survey of the heavens, in which at least 120,000 stars were examined.

(291.) His researches on double stars.

M. Struve's papers are distinguished by the elaboration of the reductions, and of the *statistical* results deduced from them. In his last publication he has made an interesting estimate of the number of true double stars in the heavens, which, it appears, is much greater in proportion to the whole number than is usually believed. But it is first necessary to distinguish those which are physically double from those which are merely apparently or optically so. The criteria on which he principally depends are—(1.) the fact of observed orbital revolution; but as this is established in comparatively few instances, he very reasonably admits (2.) a common proper motion of the two components as a proof of their connection. He thus finds the evidence for physical duplicity to be much stronger for the closer double stars, and also for brighter or nearer stars, as compared with those of less magnitude. On the whole he concludes, that of 1973 double stars, 1702, or six-sevenths of the whole, are physically connected, and that, amongst at least the brighter stars, the number of compound systems is to that of isolated stars in a ratio not less than 1 to 3, perhaps even 1 to 2.

(292.) M. Struve on proper motions.

M. Struve has also determined with extreme care the places and proper motions of the double stars; and he has formed a decided opinion, that *the proper motions diminish* on the whole *regularly with the order of magnitude*,—thus confirming the criterion of increased distance from diminished brilliancy, by that of the apparent displacement of the stars by the motion of our system.

(293.) Directs the Observatory of Pulkowa.

Besides these important works on Sidereal Astronomy, M. Struve is well known as the head and director of perhaps the best organized observatory in the world, that of Pulkowa near St Petersburg, of which he has published a very interesting description. Besides other noble instruments, it contains the finest refractor in Europe, that by Merz, 15 inches in diameter, and 22 feet focal length. The observations with this noble telescope are chiefly made by his son M. Otto Struve, the author of many good papers. We have seen in a former section (252), that we owe in great part to M. Struve the conduct of the most extensive trigonometrical operation ever undertaken.

(294.) Sir John Herschel—his astronomical career.

Sir John Frederick William Herschel, son of Sir William Herschel, whilst conversant with almost every branch of science, has devoted himself with remarkable success to the cultivation of Sidereal Astronomy. "Bearing a name honoured and revered by all, his career at Cambridge reflected upon it fresh lustre; the variety and extent of his acquirements gave him a reputation amongst his college contemporaries, afterwards fully confirmed by the not more impartial voice of mankind at large." He was senior wrangler in 1813. "Since that time he has been indefatigable as an author:—first, in systematizing the higher mathematics, and in forwarding their study in his own university;—afterwards by treatises contributed to the *Encyclopædia Metropolitana* on Sound, Light, and Physical Astronomy, which still rank among the clearest, completest, and most philosophical in our language. About the same time he wrote experimental essays on different branches of Chemistry, Magnetism, and Optics, and commenced his purely astronomical investigations, chiefly on nebulæ and double stars, partly in conjunction with Sir James South, of which the details are given in different volumes of the Astronomical, and of the Royal Society's Transactions. These memoirs collectively include a complete revision of the objects of the same description catalogued and classified by Sir

William Herschel."[1] But the most considerable monument to Sir John Herschel's love of science is the record of his four years' labours for the advancement of Sidereal Astronomy at the Cape of Good Hope, where he applied his father's methods of observation to the southern hemisphere. His *Results of Astronomical Observations*, which fill a large quarto volume, and which include "the completion of a Telescopic Survey of the visible Heavens, commenced in 1825," form one of the most considerable and most interesting works of our time. The instruments employed were a 20-feet reflector, of 18¼ inches aperture, and a 7-feet achromatic, with 5 inches of aperture. With these the nebulæ and double stars of southern skies were examined and measured, and that wonderful "Gauging of the Heavens" completed, of which I have spoken in the account of Sir William Herschel (201). There is an admirable chapter on the apparent magnitude of the stars, to which I shall refer presently, and one on Halley's comet, besides other matters of interest.

Sir J. Herschel's observations at the Cape of Good Hope.

(295.) His high character amongst his contemporaries.

Since his return to England in 1838, Sir John Herschel has withdrawn from the labours of practical astronomy, but he continues to advance different branches of science, and to expound them by his able and lucid writings in a way which has made his authority equally respected by philosophers and by men of the world. The career of Sir John Herschel has been marked by an almost total absence of the element of ambition, so often a powerful excitement in the pursuit of discovery. Had he sought notoriety and posthumous fame, he would have confined his efforts within a more circumscribed range. But his versatile talents sought their appropriate exercise in all departments of exact science, and even (it is believed) in pursuits widely distinct from these, in natural history, *belles lettres*, and the fine arts. In all this he no doubt considered simply the useful and pleasurable employment of his mental activities. Truth seemed to him as desirable whether attained by the labours of others or by his own; and in his numerous writings he has expounded these with a zest which a less generous spirit might have reserved for his peculiar achievements. What he may have lost in future fame by this enlargement of his sympathies and interests, he has gained in the respect and good-will of all his contemporaries. Sir John Herschel recently filled the post of Master of the Mint, to which, like his illustrious predecessor Newton, he devoted a considerable share of his time. His general eminence as a man of science has been acknowledged by his nomination in 1855 to the distinguished honorary position of one of the eight foreign Associates of the French Academy of Sciences.

(296.) On the orbits of double stars.

Orbits of Double Stars.—Though not absolutely the first to apply calculation to the orbits of double stars, this step in their theory may not unfitly be connected with the name of Sir John Herschel, from the ardour of his researches and the neatness of his methods. To Savary of Paris is due the merit of ascertaining the form and position of the orbit of ξ Ursæ Majoris in 1827, which was followed by a more purely analytical method by M. Encke, and one chiefly graphical by Sir J. Herschel,[2] in which angles of position of the component stars are used nearly to the exclusion of the more doubtful measures of distance. On the whole, these investigations not only confirm Sir William Herschel's anticipations, but render it highly probable that the relative orbits are really ellipses, and consequently that the law of force is that of the inverse square of the distance. The reader will find in Sir J. Herschel's Cape Observations a very curious discussion of the orbit of γ Virginis, a remarkable double star, whose interval was in 1783 five seconds and two-thirds, which diminished till 1836, when the two stars appeared united in one, as seen even in the best telescopes. This was the perihelion passage of these two suns, and the angle of position must then have varied (could it have been measured) at the rate of 70° per annum, or 1° in 5 days. The following are some of the best ascertained periods of sidereal revolutions in years:—ζ Herculis $36^{y}\cdot4$; ξ Ursæ Majoris $61^{y}\cdot5$; α Centauri 77^{y}; p Ophiuchi 80 or 90^{y}; σ Coronæ Borealis 600 or 700^{y}. M. Mädler, Admiral Smyth, and Mr Hind, have added much to our knowledge of this interesting subject.

(297.) On the brightness of stars.

Brightness of Stars, and Variable Stars.—Sir John Herschel has attempted by an elaborate system of inter-comparison to assign the correct relative brightness of the stars, and to give precision to the ordinary terminology of Magnitudes. His "Method of Sequences" described in his Cape Observations, appears to be one of the happiest specimens of generalization which experimental science affords. Whilst regretting the impossibility of here giving even the slightest sketch of it, I cannot but recommend it to the student of natural philosophy as a model of research. Having ascertained, in a way independent of every sort of hypothesis, the relative brightness of the stars upon the scale of Magnitudes usually adopted, but which is wholly arbitrary, Sir J. Herschel proceeds, by properly photometric methods, to give a scientific precision to this notation; and he arrives at this singular and fortunate conclusion, that by adding a small and constant correction to the received scale of Magnitudes, the numbers will represent *the distances of the respective stars from our system on the supposition of an intrinsic equality in the brightness of the stars themselves.*

(298.) Variable stars.

This subject naturally includes that of Variable Stars, which may be divided into those which undergo periodic or irregular fluctuations, and the latter class may embrace new stars, and stars which have disappeared. The last two hundred years have not presented any such astonishing phenomena as the new stars recorded in the sixteenth and seventeenth centuries; but singular variations in the brightness of some of the most conspicuous stars, as α Orionis and η Argûs, have been discovered by Sir John Herschel. Several stars of short and irregular periods of varying brightness were recorded towards the close of last century. But upon this very interesting subject I must content myself with referring to the details given by Professor Argelander in the third volume of Humboldt's *Cosmos*.

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[1] *Quarterly Review*, vol. lxxxv., p. 2.

[2] *Astronomical Society's Memoirs*, vol. v.

(299.) Lord Rosse—his reflecting telescopes.

EARL OF ROSSE. *Latest observations on Nebulæ.*—It is a remarkable circumstance, that as the reflecting telescope was a British invention, so the more important improvements and applications of it have been almost confined to the United Kingdom. It is also worthy of notice that the manufacture has prospered more in the hands of amateurs than of regular opticians. Sir William Herschel appeared at one time to have brought the invention to its highest perfection, but the Earl of Rosse has made an important step farther; not only by constructing a larger telescope than had been made before, but by adapting machinery driven by steam power, to the grinding and polishing of the mirror; so that the largest speculum may be finished with nearly the same accuracy and expedition as the smallest. The *chef d'œuvre* of Lord Rosse is a telescope of 6 feet aperture, and 53 or 54 feet of focal length. It was completed in the latter part of 1844, and erected at Parsonstown in Ireland.

(300.) Difficulties encountered.

Let me here record the important fact, that neither rank nor wealth could absolve Lord Rosse from those toils and disappointments which attend all new and original efforts. There is no royal road to such triumphs. The Irish nobleman owes his success entirely to his unwearying perseverance and mechanical skill. Even his assistants were countrymen instructed by himself in his own workshops, where the very steam-engine which drives the polisher was fabricated. His labours to improve the telescope date from 1828 (when he was Lord Oxmantown), or even earlier, and they appear to have been unremitting until 1844; indeed I might say until the present time. Commencing with a variety of ingenious attempts to correct spherical aberration, and to overcome the extreme difficulty of procuring large castings of so excessively brittle a material as speculum-metal, they terminated in the rejection of all minor helps and expedients, and in the fortunate completion of immense mirrors at a single casting, and of correctly parabolic figure when ground and polished. The speculum of his largest telescope weighs four tons. It was polished in six hours, and its surface is considerably more than twice as large as that of Sir William Herschel's forty-feet instrument.

(301.) Methods of construction.

We cannot enter into the details of the methods, which evince no small mechanical skill and scientific ingenuity, together with a perseverance admirable in itself.[1] I will only mention how the upper and lower surfaces of the casting were made to cool nearly equally fast. To effect this the lower surface of the mould (which naturally retains the heat more than the upper) was made of iron, a good conductor, whilst the upper surface was made of sand. This effected the purpose; but it being found that air bubbles entangled in the fluid metal could not escape beneath, and injured the casting, the iron bed was constructed of hoops set on edge and closely packed, the crevices allowing the escape of air, whilst the cooling proceeded as before; and this ingenious contrivance was perfectly successful.

(302.) Application to Nebulæ, and its results.

Many difficulties in detail have been found in the mounting and use of so gigantic a mass, particularly on account of the distortion of the mirror by flexure. But these have gradually been surmounted by Lord Rosse. His published observations (*Philosophical Transactions*, 1850) relate almost entirely to objects of the class of nebulæ; and as I cannot enter into details, I may state the general results in two or three sentences. (1.) As might have been expected, many nebulæ which resisted the power of former telescopes (for, except in rare instances, nothing greater than eighteen-inch apertures have been directed to them) have been "resolved" into stars by the six-feet speculum. (2.) The aspect of a great number of nebulæ described by the two Herschels is materially modified by the power of the telescope to embrace the fainter prolongations of these singular objects. In general, the symmetrical forms are very much cut up and confused, and in many cases vanish altogether. (3.) Instead of these, a certain species of symmetry, of a vague yet very remarkable description, has been detected by Lord Rosse, probably for the first time. It is a spiral arrangement of the nebulous coils round a centre, resembling somewhat the spiral emanations of revolving fireworks. The well-known nebula No. 51 of Messier's Catalogue shows this in a remarkable manner.

(303.) Some observations have been made upon the moon. It is much to be desired that these were continued, and that the planets could also be observed; but I believe that the climate of Parsonstown affords but few nights favourable to observation.

(304.) Henderson—his birth and character.

HENDERSON AND BESSEL. *Parallax and distance of the Fixed Stars.*—THOMAS HENDERSON, at one time government astronomer at the Cape of Good Hope, and subsequently professor of practical astronomy in the university of Edinburgh, and his

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[1] For a comparison of Lord Rosse's and Messrs Naysmith and Lassell's (subsequent) methods of mechanical grinding and polishing, see *Astron. Soc. Notices*, vol. ix. p. 110. In Lord Rosse's apparatus every stroke of the polisher is almost a straight line; in Mr Lassell's it never is.

Majesty's astronomer for Scotland, was born at Dundee, in Scotland, 28th December 1798. He died at Edinburgh 23d November 1844. His career was an instance of the conquest of disadvantages of many kinds by a patient, devoted, and conscientious spirit, and of the attainment of a station of great eminence in the world of science by singleness of purpose, and an ardent love of knowledge.

(305.) Henderson's scientific progress.

He was fortunate in having Mr Duncan (now of St Andrews) as his instructor in mathematics at Dundee, and it was "while employed as an attorney's clerk in a provincial town that he laid the foundations of that extensive acquaintance with astronomy for which he was afterwards distinguished." It was his good fortune to attract in Edinburgh the discerning notice of Sir James Gibson-Craig and his family; through whose influence, probably, he obtained professional employments of a kind which permitted him considerable leisure, and even gave him an opportunity of forming scientific acquaintances in London. His early tastes were towards the practical calculations of astronomy, such as occultations and ephemerides; and from his merits alone he was commended and patronized by Dr Thomas Young. Had that great man lived, his promotion to a scientific post would have probably been earlier. As it was, he obtained in 1831 an honourable, and, for him, lucrative appointment as astronomer at the Cape; at the sacrifice, however, of quitting his native country. In the thirteen months during which he held that situation, he performed an amount of *first-rate* work in practical astronomy which may bear a comparison with any similar effort. Charged with an instrument notoriously defective (Jones's circle), he had to examine its errors and their compensations; and it is no small credit to him to say that with such an indifferent tool he carried off a prize which had been the aspiration of so many astronomers before him—the determination of the parallax of a fixed star.

Appointed to the Cape Observatory.

(306.) The parallax of fixed stars,

We must not go back to the history of this problem previous to the nineteenth century, when alone instruments were so far perfected as to give results by which a parallax, or displacement by perspective of a star in consequence of the earth's motion had a chance of being discovered, since it *certainly* does not amount to above a second or two, probably never attains even the former amount.

(307.) had been investigated by Pond and Brinkley.

The earlier part of this century witnessed a memorable contest on this subject between Mr Pond, the Astronomer-Royal, and Dr Brinkley, afterwards Bishop of Cloyne; the former founded on observations at Greenwich, the latter at Dublin, both with instruments of great power, being meridian circles of the largest size. It is sufficient here to note that Dr Brinkley attributed to some of the brighter stars, such as α Lyræ, a parallax of 2″·5 (which, however, he afterwards reduced to little more than 1″), whilst Mr Pond could arrive at no such result. There is no doubt that Mr Pond was correct.[1]

(308.) Henderson discovers that of α Centauri.

The first case of parallax which was determined with some certainty by the use of ordinary meridional instruments was that of α Centauri, a bright star of the southern hemisphere, which was deduced by Henderson from his observations at the Cape long after they had been made, and what is perhaps still more satisfactory, made without reference to this particular question. The result, which gave to this star an annual parallax of 0·91 of a second, is believed to be correct, because it has been confirmed by Mr Maclear, Henderson's successor at the Cape. It may, however, be not unreasonable to desire that the observations should be repeated in another locality, and with a different instrument; for it has not been unusual (as in the case of Brinkley) to obtain under the same circumstances perfectly consistent, yet erroneous, and therefore inexplicable results.

(309.)

The very considerable amount of parallax in this instance, corresponding to a large proper motion (3″·6), gives a strong independent probability that it is not materially erroneous; and in this respect the most competent and impartial historians of science have given full credit to Mr Henderson for having, by superior skill in the use of his instruments, and the happy choice of an object, made a discovery which so many eminent observers had long sought for in vain.

(310.) Bessel's observations on 61 Cygni.

Subsequent to the date of Henderson's observations, but before their publication, Bessel (whose biography we have given in Section 3 of this chapter) determined the parallax of the star 61 Cygni, in a different way. It was a happy suggestion of Galileo, that if two stars be selected *apparently* near one another, but really disconnected, and having very unequal magnitudes (therefore probably at very different distances from our system),—and if the apparent angular distance between the two stars be measured from opposite parts of the earth's orbit, it must sensibly vary by an obvious effect of perspective. It was in pursuit of this happy idea that Sir W. Herschel discovered the fact that the connection of such pairs of stars is often *real*, not *apparent*—but it was Bessel who, guided in his choice of an object by the critical character of the

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Notice of Brinkley, Bishop of Cloyne.

[1] John Brinkley, Bishop of Cloyne, was born in England, and educated at Cambridge, where he was senior wrangler in 1788. He acted for a short time as Maskelyne's assistant at Greenwich, and was subsequently appointed Professor of Astronomy at Dublin, where he made many excellent observations, especially those on Nutation and Aberration. Brinkley ought to have been mentioned in Art. (30) of this Dissertation, as having contributed materially to the progress of the study of the Continental Mathematics in the United Kingdom.

considerable proper motion of an otherwise unconspicuous star, first reduced Galileo's theory to successful practice. The details of this elaborate investigation have been considered by competent judges as among the happiest specimens of astronomical induction; and like Professor Henderson's, they have also had the advantage of subsequent and still more independent corroboration. Professor Johnson of Oxford, using, like Bessel, a divided object-glass micrometer (or heliometer, as it is not very appropriately called, never being applied to the sun), has obtained results for the parallax of α Cygni almost identical with Bessel's, which was 0·35 of a second. I am sorry that my limits will not allow me to explain more particularly the details of Bessel's method, which, however, may be found in several modern works on astronomy.

(311.) M. Peters. M. Peters of the Observatory of Pulkowa has announced several additional parallaxes, all determined with the aid of a meridian instrument. He has even attempted to infer the *mean* parallax of stars of the 1st, 2d, &c. magnitudes, which M. Struve has compared with his estimate of relative distance derived from other considerations; but the numbers of ascertained parallaxes, as well as their amount, are too small, and the anomalies still too apparent (as in the case of the star No. 1830 of Groombridge's Catalogue), and the parallactic distances too often inverted on the scale of brightness, to allow us to attach much importance to these generalizations.

CHAPTER IV.

MECHANICS OF SOLID AND FLUID BODIES, CIVIL ENGINEERING, AND ACOUSTICS.

§ 1. WATT.—*Condition of Practical Mechanics previous to the time of Watt. His genius for the application of Science to Practice. His successive Improvements on the Steam-Engine. Steam Navigation.*

(312.) James Watt. JAMES WATT may be considered as the most distinguished *practical* man of science of the last century, or even for a much longer period. But this is not all. Few men achieve such a reputation as his without having done more than originate a great invention for the use and benefit of mankind in all ages:—He also taught men to raise the useful arts to a new dignity,—to marry them to genuine, unpretending, and inductive science,—to disparage ignorance and empiricism, and to render the labours of the workshop subservient to intellectual progress.

(313.) Relation of engineering to physics. I have attempted, in the first chapter of this Dissertation, to place the scientific part of engineering in its due relation to pure physics, and I have compared the relation between them to that subsisting between Mathematics and Physics—the one as an instrument, the other as an end. Now it was this, in particular, which made Watt the important character he really was. He brought out the dependence of the former subjects, as Newton and others had successfully taught and demonstrated that of the latter.

(314.) State of mechanics in the seventeenth century. To appreciate Watt's merit, we must compare the purely mechanical contrivances of the period preceding the date of his improvements on the steam-engine with those of a similar space of time succeeding it. In the former we find multitudes of contrivances *on paper*—ingenious, indeed, but many of which could not be executed; the greater part of the remainder could not be carried into effect through want of knowledge in the inventor. We have large promises of "semi-omnipotent engines," perpetual motions, "quintessences of motion," and the like, mingled with trivial mechanical toys; or we have elaborate diagrams of mill-gearing, lathes, fountains, and sawing machines without end, illustrated with showy and expensive plates, but destitute, for the most part, of the slightest novelty of principle, or truly mechanical skill in application. Here and there, no doubt, elegant and appropriate contrivances for communicating or sustaining motion occur; but nearly all the best forms of elementary machinery were of remote antiquity, excepting those connected with clockwork, which, including the great and truly scientific application of the principle of Isochronism, formed the only considerable step in philosophical mechanics for very many years previous to the conception of the steam-engine. The statical part of mechanics had made more progress. Masonry and Carpentry had attained a degree of perfection in many respects admirable, under the Italian and Norman architects; but the really difficult theory of machinery in motion was little understood before Watt's day, and the knowledge which then existed was unassociated with practical skill or commercial enterprize. It could be found only in profound treatises of theoretical mechanics, and in experimental courses of natural philosophy. The sources of power were almost exclusively those derived from simple gravity and the impact of fluids. It was not, indeed, the good fortune of Watt to be the first to employ the admirable properties of steam as a source of power; but he was almost the first to study them as a philosopher, and to apply, with exemplary patience and skill, principles sought in the laboratory, to make available the most convenient of *all motive forces*. This was done by means of a series of contrivances so ingenious—so strictly connected by scientific relations—as to be a model of experimental research, quite as much as a triumph of mechanical art.

(315.) Philosophical spirit infused into practical mechanics by Watt.

Such combinations of theory and practice have now become far from rare. They have followed the march of physical learning, they have borrowed from it, and they have contributed to it. But it was Watt who chiefly gave the happy example. Himself by education and habit strictly a mechanic, he had the peculiar merit of apprehending the value of theory, and of acquiring a kind of knowledge then altogether uncommon amongst persons of his profession. He was no doubt a successful speculator, and a shrewd ingenious man besides; and this, his ostensible character, constituted possibly in the eyes of many his world-wide celebrity. But such considerations were little likely to influence the opinions of contemporary scientific men well qualified to judge, and least of all of eminent foreigners, who generally regard with little partiality the presumed commercial character of their insular neighbours. Dr Black, who was by no means prodigal of praise, termed the steam-engine, as improved by Watt, "an invention which is in its present state the master-piece of human skill," not "the production of a chance observation, but the result of deep thought and reflection, and really a present by philosophy to the arts."[1] Professor Robison, who knew Mr Watt intimately, was even more enthusiastic in his appreciation of his genius; and Sir Humphry Davy, in a speech manifesting a just estimate of his peculiar merits, did not hesitate to place him on a level with Archimedes.[2] But a testimony more authoritative and unbiassed than any of these, is the fact that Watt was elected first a corresponding member of the French Institute, and finally one of the eight foreign Associates of the Academy of Sciences. This honour, to which so few can attain, which Newton once owned, and which now graces or lately graced the names of Young, Humboldt, Oersted, Brewster, and Robert Brown, is a sure passport to scientific immortality. Here, at least, no utilitarian pride, nor even the laudably patriotic emotion of gratitude to one who had proved, in more ways than one, his country's benefactor, can be supposed to have influenced in the remotest degree his election.

Estimate of Watt's genius.

(316.) Having said thus much on the position to which Watt's inventions entitle him in the narrative of the history of science, we may refer with brevity to the generally well-known improvements of the steam-engine, in which they mainly consist. In Sir John Leslie's Dissertation, a space of but a few lines has been devoted to them, which seems inadequate to their importance. For details, however, we must refer to the articles in the Encyclopædia where they are explained at full length.

(317.) Origin of the steam-engine.

No doubt we cannot in strictness call Watt the inventor of the steam-engine. The grand principle of rendering the heat contained in steam available as an economical source of moving power may be traced so far back that we lose the clue altogether in the obscure, or impracticable, or simply puerile shapes in which the idea was contained. Even in the time of Worcester (1663) we must be allowed to doubt whether the history of the steam-engine had outgrown the mythical stage; Papin, indeed, proposed a piston and cylinder in which the vacuum was produced by steam instead of by the air-pump (as already suggested or practised by Guericke); but Savery (1698) was the first who constructed a steam-engine, and applied it to the drainage of mines. His invention included the two capital properties of steam, its power of producing a vacuum by condensation, and its elastic force at high temperatures. A few years later the piston-form was introduced or re-invented by Newcomen and Cawley, as well as the valuable expedient of producing condensation by a squirt of cold water injected into the cylinder; and in this condition the Atmospheric Engine remained with slight improvement for above half a century, doing the work for which it was invented,—the pumping of water out of shafts (the pump being moved by a chain attached to the end of a horizontal oscillating beam),—wherever economy of fuel was unimportant. Such was the case at coal pits, but in other mines, usually situated remote from coal, it was of comparatively little use, on account of the enormous consumption of fuel.

(318.) James Watt's early history,

James Watt was born at Greenock in 1736, and, owing to feeble health, seems to have enjoyed little advantage from regular tuition of any kind; which was, however, to a great extent made up for by the intelligent spirit with which he acquired knowledge without assistance on a great variety of subjects. At the age of nineteen he proceeded to London, where he learned mathematical-instrument making, but he soon returned to Scotland, intending to pursue that business in Glasgow. Here he met with obstacles, but finally, by the patronage of Dr Adam Smith, Dr Black, and other professors, he was established as instrument-maker to the university within the college buildings. I mention these details because they show that Watt, as early at least as 1757, had been favourably noticed by the most celebrated professors then in Glasgow, and had received a special pledge of their good will.[3] It is evident that the professors of Che-

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[1] *Lectures*, i., 181.

[2] Speech at Freemasons' Hall, preserved in Arago's Eloge of Watt, and in Davy's Works, vol. vii.

[3] It appears from Mr Muirhead's work on *The Origin and Progress of the Mechanical Inventions of James Watt* (published since the greater part of the text of this section was written), that Watt's introduction to the college took place "through the instru-

and connection with Dr Black.

mistry and Natural Philosophy (Dr Black and Dr Dick), who had obtained for him his appointment, must have been also his chief academical employers; and we may safely conclude that Watt constructed much of Dr Black's apparatus, as he was certainly admitted to intimate and confidential intercourse with that great and amiable man. Dr Black removed to Edinburgh in 1766, but the friendship which he had extended to the young mechanic remained unaltered during their joint lives, although their personal intercourse must have been extremely slight after that time. Now Watt's first thought of improving the steam-engine dates (as we shall see) from the session 1763–4, the last but one of Black's stay in Glasgow; their intimacy was therefore fully established by that time; and we find Watt acknowledging his "obligations to him for the information received from his conversation, and particularly for the knowledge of the doctrine of latent heat;"[1] and we also find that during Watt's experiments on steam subsequent to the last-mentioned date, Black was cognizant of them, and assisted in their contrivance.[2] Moreover, Watt admits Dr Cullen's well-known experiment of reducing the temperature of ebullition under the air-pump to have been one of his starting points in the improvement of the steam-engine.[3] Yet this experiment was not *published* until 1770,[4] and Watt must have heard of it from Black himself, or from some one attending his lectures, where the fact was almost certainly mentioned. Whether *formally* a student of Dr Black's chemistry class or not, it is therefore evident that Watt enjoyed advantages in the prosecution of experimental physics which nineteen-twentieths of enrolled students never attain. He had the privilege of unreserved personal intercourse, amounting at last to intimate friendship, with the first authority of the last century on the subject of Heat, and one of the most cautious and accomplished of inductive philosophers.[5] Watt's eminent merits, and doubtless his merits alone, gained him this happy position; but had he remained either at Greenock, or with the optician in Cornhill, he might have failed to combine so admirably as he did the character of the practical man and the philosopher. His place in science was well typified by his position in Glasgow. His was "the *workshop* within the *College*." Whilst the laboratories of the classes of Chemistry and Natural Philosophy must have been his familiar resort, his own rooms were frequented by the most intelligent students, including his contemporary Dr Robison, where subjects of science particularly connected with mechanics were diligently canvassed. The extent of his knowledge and the variety of his resources were fully tested, and the result, as stated by the generous pen of Robison, was a conviction of the superiority of Watt in these respects to any of his contemporaries.

His position in Glasgow College.

(319.) Watt's first experiments on steam.

It is a fact worthy of note that the immediate occasion of Watt's improvements was the commercial consideration of economy. In 1763 or 1764, being called on to repair a model of the Atmospheric Engine in the Natural Philosophy class at Glasgow (which model is still preserved), he found the amount of steam expended in heating the cylinder at each stroke to be so great that the boiler was insufficient to supply it properly. He then commenced experiments on the amount of steam thus consumed, and on the means of diminishing it. Though the primary object was the repair of a model, it is not to be doubted that Mr Watt had in view the practical improvement of the engine on the great scale, with the use of which in the coal-fields of the west of Scotland he was probably familiar, having the intention of becoming himself a civil engineer, and being already acquainted with the writings of Desaguiliers and Belidor.[6]

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mentality of his mother's kinsman Mr George Muirhead, who had then (1754) just exchanged the professorship of oriental languages for that of Latin." It will be seen that this refers to a period antecedent to his journey to London.

[1] Letter to Dr Brewster in Robison's *Mechanical Philosophy*, ii., p. v.

[2] Robison's *Mechanical Philosophy*, ii., 115, *note* (by Mr Watt).

[3] *Ibid.*, p. vii., and 114, *note*.

[4] In the *Edinburgh Physical and Literary Essays*, vol. ii., Dr Black (who was intimate with Cullen) knew of it at least in 1757. *Lectures*, i., 525.

[5] It is perhaps unfortunate that Mr Watt, when on the verge of fourscore, contrary to his own intentions, but yielding to "the representation of friends," recorded a complaint that his best friends, Black and Robison, had refused him his due share of merit in the improvement of the steam-engine, and disclaimed, as injurious, the appellation of "a pupil of Dr Black" (letter to Dr Brewster in Robison's *Mechanical Philosophy*, vol. ii., p. v.) Admitting (as he does on the same page) that the doctrine of latent heat was due to Dr Black, and that he first learnt it from him, he adds, "this theory did not lead to the improvements I afterwards made in the engine," p. viii. No one ever ascribed to Black the beautiful invention of a separate condenser, but even Watt's most ardent eulogists (Lord Brougham and M. Arago) admit that the theory of latent heat "forms the key to the economical appreciation of the steam-engine." So far was Watt from being independent of Dr Black's assistance in this matter, that he himself tells us twice over, in substantially the same language, that when in the course of his experiments on the model engine in Glasgow College in 1764 he was "*at a loss to understand* how much cold water could be heated by so small a quantity in the form of steam," he "*applied to Dr Black*, and *then first understood what was called latent heat*" (Robison, ii., p. v.; also p. 116, *note*). Mr Watt *might* have been the discoverer of latent heat, and the solver of his own dilemma, had not Dr Black been at hand. It is the highest compliment we can pay him to say that such an achievement was not too much to expect from him.

[These conclusions are fully substantiated by the interesting documents lately published by Mr Muirhead in the *Correspondence of Watt on the Composition of Water*, p. 6, and in his *Mechanical Inventions of James Watt*, vol. i., p. lxxxi.; vol. ii. pp. 116, 118, 119, 275. In the last-cited passage Watt himself fixes the date and manner of his receiving from Dr Black his knowledge of the doctrine of Latent Heat. He says, "I myself never attended his (Dr Black's) lectures; but the doctor explained his doctrines to me about the year 1763."] *Note added during printing.*

[6] See Mr Watt's own narrative in Robison's *Mechanical Philosophy*, ii., 113, *note*; and in Mr Muirhead's *Mechanical Inventions of James Watt*, vol. i.

(320.) Imperfections of atmospheric engine.

When Watt discovered by means of his model that the condensation and loss of steam in the cylinder at every stroke of the piston exceeded that which is usefully employed in producing the vacuum, he proceeded very methodically to ascertain the chief numerical data or constants upon which the working of steam-engines depend ; as, the bulk of steam of given elasticity compared with that of the water producing it, the elasticities of steam at different temperatures, especially above the boiling point, the evaporating power of a pound of coals, and finally, the expenditure of steam and of injection-water for a single stroke. The last, the amount of cold water required effectually to condense the cylinderful of steam, appeared so very large that it at once betrayed the source of the wasteful expenditure of fuel. All the heat which was abstracted by the injection-water had to be supplied afresh at a vast expense of steam, and consequently of coal, before a fresh stroke could be made. The mere amount of steam necessary to fill the cylinder and elevate the piston was a trifle in comparison. He naturally ascribed it to the absorption of heat by the material of the cylinder, which no doubt was an important element; and he tried cylinders of different materials, and ascertained (in most instances for the first time) the *specific heats* of the substances used. But still the amount of injection-water remained unaccounted for, and the regulation of it was the great difficulty of the old engine. If a tolerable vacuum was desired, the cylinder must be flooded with cold water, and all the heat abstracted must be restored before the next stroke was produced. If, on the other hand, the injection was imperfect, so that the condensed steam and water together retained a high temperature, an atmosphere of vapour so elastic spoiled the vacuum, and in many cases the working efficiency of the engine was reduced to about half of the atmospheric pressure.

(321.) Watt's principle of separate condensation.

The theory of latent heat, showing that steam contains as much heat as if the water yielding it had been raised through 1000° of temperature, gave a clear explanation of the enormous amount of injection-water necessary. How to escape from the difficulty was another question, which was solved solely by Mr Watt, who, early in 1765, first conceived the idea of retaining the cylinder always at the boiling heat, and effecting condensation in *a separate vessel* kept constantly as cold as possible, in which injection should also take place, and into which the steam of the cylinder would spontaneously rush, on a communication being opened at the proper instant. The success of this device was complete, and it was speedily followed by a series of admirable and mutually dependent improvements which Watt introduced. To keep the cylinder as warm as possible, it was first provided with a cover, through which the piston-rod passed by means of a stuffing-box. Then steam itself was employed to press down the piston, instead of atmospheric air which cooled the cylinder injuriously.

(322.) Double-acting engine.

Parallel motion.

Having thus steam on each side of the piston, the step was easy to make the engine a *double-acting* one; so that the volume of steam which by its elasticity impelled the piston during its descent, being thrown into the condenser, produced the vacuum necessary to make the ascending stroke equally advantageous.[1] But in pumping-engines, which had hitherto been the main employment of steam, or *fire* engines (as they were then called), it was sufficient that the power was produced in *one* direction, that is, to lift the pump-rods ;[2] but the double action of a pushing and pulling force was evidently applicable to every sort of machinery by the use of a crank and fly-wheel. A difficulty, however, was experienced in applying this push-and-pull movement to the oscillating beam which had so long formed a part of the atmospheric engine, and which it was so convenient to use. Mr Watt obviated it with his customary sagacity, and succeeded in inventing a connection of rigid jointed links which effectually united the piston-rod with the end of the beam, the former moving in a vertical straight line, the latter in a circular arc, so that pressure was transmitted in the manner of either push or pull without the slightest practical inconvenience. No doubt the *locus* of the motion of the piston-rod head is not rigorously straight. It is, when fully developed, a curve of the fourth order, resembling a very elongated figure 8 ; but the portion of the curve in use is practically straight. This happy solution, the most elegant perhaps in the science of pure machinery, or kinematics, was not the result of a formal mathematical research, but presented itself to the mind of Watt, as he tells us, almost intuitively. It became from henceforth an important element of mechanical combinations.

(323.) Expansive working.

Other methods of producing direct rotation occurred to the ingenious mind of Watt, and many of them were shown to be practicable by being actually executed in model size. But the next great practical improvement introduced by him was the principle of *expansive working*, whereby a saving of steam is produced (particularly in single-acting engines), second in importance only to the result of the separate condensation. This consists in allowing the steam to flow in upon the piston during only the first part of the stroke ; the rest being completed partly by the inertia of the moving machinery, but chiefly by the continuous though constantly diminishing elasticity of the steam as it expands and fills the entire cylinder.[1] It is evident that, in the extreme case, the work required (in pumping) will be accomplished if the piston reach the end of the stroke just as its momentum is exhausted, and that, on the other hand, if the pressure of the steam remain constant throughout, the velocity will be a maximum just when the work being done by the machine is suddenly completed, and so much moving power will be wasted. A medium distribution produces the most favourable result in practice, and it depends entirely upon the ratio between the resistance and the effective pressure of the steam what this most favourable proportion will be. In the single-pumping engines of Cornwall, in which the economy of fuel is carried to the highest perfection, it frequently happens that not more than *one-eighth* of the stroke is performed under the full pressure of the steam, which acts expansively during the remainder of the stroke; but these engines, though condensing, are moved by steam of four times the elasticity of the atmosphere. The Cornish engines have been very elaborately perfected, and they have been more carefully tested in respect to performance than any others. It is perhaps not too much to say that they do not contain a single contrivance of any importance (beyond of course what they have in common with the atmospheric engine), which was not the unaided invention of Mr Watt.

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[1] This happy idea seems to have been suggested by Dr Small of Birmingham in a letter to Watt, of date 5th November 1769. "I see no reason . . . . . why you should not condense at both ends of your cylinder, and drive all before you, back stroke and fore stroke."—*Mechanical Inventions of James Watt*, i. p. 81. The uncommon sagacity of Dr Small, and the important services which he rendered in many ways to Watt, come out clearly for the first time in this work.

[2] So associated were these engines with the operation of raising water, that we find they were at one time used to supply common water-wheels with a constant stream, and thus to produce continued motion for mill-work, &c.

Cornish engines.

(324.) Their perfection.

In the Cornish engine we see the Energy of Heat rendered available to an extent which the inventor himself would at one time have thought scarcely credible. The combustion of a bushel of coal which in a Newcomen's engine improved by Smeaton was capable of raising 3,000,000 pounds through one foot, in Watt's improved pumping engine raised 20,000,000 pounds the same height. But by the indefatigable skill and perseverance of engineers the Cornish pumps now yield at least *five times* the last amount. This, however, is not the place to enter upon these details, nor can we stop to particularize the other and various mechanical inventions introduced by Watt in the form of valves, governors, and steam-indicators. Still less can we enlarge upon the endless and still multiplying applications of this admirable moving power, which is as capable of superseding the greatest natural forces hitherto applied by man to the useful arts, as it is adapted by its easy regulation to replace human industry in the most delicate operations; "the trunk of an elephant, which can pick up a pin or rend an oak, is as nothing to it."[2]

(325.) Application of steam to navigation.

Of the applications of the steam-engine with which Mr Watt was less immediately connected, its adaptation to locomotion in the case of ships in the last century, and in that of railway trains in the present, have been the most striking, and fraught with consequences the most important to mankind. Of the latter we shall have occasion to speak in a future section; of the origin of steam navigation we may here say a very few words. Passing over projects which never were realized, of moving barges by steam, or other inanimate power, against wind and tide,—such as those of Worcester, Papin, and Hulls,—we find that the first experiment entitled to be called successful was made by Mr Miller of Dalswinton in Scotland, conjointly with Mr James Taylor, tutor in his family, who together formed the project of moving vessels by means of paddle-wheels driven by a steam-engine, and realized it with the aid of Symington, a practical engineer. As we shall also find in the case of steam-carriages, the *idea* of the application of the steam-engine to move ships was already a familiar one to the minds of many persons about the middle of the last century. To put it in practice with advantage was the step required. Mr Miller's first boat was launched on Dalswinton Loch in Dumfriesshire, in October 1788, and attained a speed of five miles an hour. The subject was pursued by Symington and others. In 1789 a larger vessel was propelled on the Forth and Clyde Canal. Subsequently, however, the invention languished. The want of co-operation, of capital, and ingenuity, naturally extinguishes many valuable inventions. Watt himself was only rescued from the same difficulty by the unusual intelligence of Boulton and Small, his coadjutors at Birmingham. Symington was less fortunate, as well as probably less meritorious; and though it is well established that Fulton, who passes on the other side of the Atlantic for the inventor of steam-ships, had seen the relics of Symington's second experiment, we must do the Americans the justice to say that the application of steam to navigation first flourished in the United States. In 1807 Fulton started a river boat with an engine of Boulton and Watt. In 1813 the example was tardily imitated on the Firth of Clyde. The subsequent improvements need not here be specified. They have been very great and striking, but with the exception of the recent substitution of the screw-propeller for paddle-wheels, they scarcely involve any new principles.[3]

Miller—Taylor.

Fulton.

(326.) Personal character of Watt.

We may briefly close what we have to say of Mr Watt personally. His health was feeble from childhood, but being blessed with much calmness of temper he prolonged his life to a great age, and passed through its struggles, though they were to him considerable, without serious injury. Vexatious lawsuits connected with his valuable patent rights afforded him but too much occupation and anxiety. He wrote little, and he did not covet fame. He was fond of chemistry as well as mechanics, and was well acquainted with the theory and practice of that science as it then existed. He put forth opinions on the chemical constitution of water which, in the judgment of some, entitle him to contest priority in the discovery with Cavendish. He must have been versed in mathematics in his early years, as we learn from his friend Dr Robison, but there is no evidence that he ever attempted a strict theory of his own engine. Nor were his successors in this respect more fortunate. The best practical writers on the steam-engine, up even to a late period, gave most rude and inaccurate rules for computing its effects; and it is to a Frenchman, M. de Pambour, that we owe the first philosophical, and, at the same time, elementary analysis of this noble machine.

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[1] The double-acting engine was planned in 1774 or 1775. The expansion principle was first used in 1776; the parallel motion was patented in 1784.—Watt's Notes on Dr Robison's Article. Robison's *Mech. Phil.*, vol. ii.

[2] Lord Jeffrey.

[3] For farther details on the history of *Steam Navigation*, see that article in the Encyclopædia; and Mr Bennet Woodcroft's work on the subject, London, 1848.

(327.) Personal character of Watt, continued. Much light has been thrown upon the character of Watt by the recent publication of his correspondence by Mr Muirhead.[1] We there see the pressure of physical infirmity, and mental despondency and indifference, under which he laboured from boyhood. We learn the accumulated difficulties, arising from the backward state of the mechanical arts in his time, which delayed for years the successful prosecution of his happiest, and what would appear in our day most easily realized, conceptions. We see him at times ready to abandon fame and profit for the enjoyment of the humblest competence with tranquility. We find him, mechanic though he was, shrinking from possible collision with the opinions or interests of others, and in his early as in his latest days, solicitous to avoid responsibility. He had, in a word, throughout, the finely strung susceptibility of a man of genius, singularly at variance with the necessity he was under of pushing his way in the world, and of turning his inventions to the best commercial account. Providentially he was thrown in the way of friends to whom, by his private character, he was greatly endeared, and who supplied the elements necessary to the successful prosecution of his schemes. The sanguine zeal of Roebuck, the commercial sagacity of the capitalist Boulton, and not least, the sympathizing friendship of Dr Small, who was well fitted by his character and attainments to mediate between Watt and the other two, were all essential to the realization of the improved steam-engine.

(328.) Close of his life. When Mr Watt was finally relieved of the oppression and chicaneries of his opponents in the courts of law, he was settling down into a peaceful old age. He probably hoped to live over again some of the scientific passages of his youth in sympathy with his second son, Gregory, who possessed a decided taste for science, but was unfortunately early cut off. Respected and beloved by a large group of friends, many of whom survived him, and admired by a far wider circle, he died at Heathfield, near Birmingham, 25th August 1819. Statesmen, philosophers, and men of the world, united in extolling the worth of his character and the greatness of his genius.

§ 2. Robison.—*Application of Statical Principles to Engineering—especially to Practical Masonry.* Coulomb.—*Friction—Force of Torsion.*

(329.) Robison a practical philosopher. The name of Robison may perhaps not appear to be sufficiently identified with any great discovery to merit a place in this condensed sketch of the progress of science biographically illustrated. Were there no other claim, I should consider it a sufficient one to entitle him to at least a brief notice, that he was by far the most important, and, as M. Arago has justly called him, " most illustrious contributor" to the earlier editions of the *Encyclopædia Britannica*. But he was also a philosopher in a high sense of the word. His knowledge was multifarious in no ordinary degree. He had little of *pretension* to originality, yet he brought to bear upon matters of science an unfailing amount of excellent common sense, and his personal acquaintance with the Arts which may be called Philosophical far exceeded, I imagine, that of any man of his time. Though not without his prepossessions, he was generous in the highest degree in his estimation of others, who in some sense might have been considered his rivals; he was eminently patient in his study of the works of his contemporaries, and in his published writings he laboured to render the results generally accessible to ordinary readers, by means of laborious abstracts, intermingled often with highly original views; and he explained them with conscientious energy in his lectures to the students of Natural Philosophy, whom for thirty years of his life it was his pride and pleasure to instruct. Amidst these congenial labours he found little time for making prolonged original trains of experiment, though the specimens which he has almost incidentally left us give the fullest proof of his ability in this respect; and the explanation is, I have no doubt, to be found in the peculiar circumstances of his early life. Until his settlement in Edinburgh, he passed his time in a series of active pursuits, having much more of the character of stirring practical life than of literary repose or scientific contemplation. He was thirty-five years old when he began to lecture in Edinburgh; and though an excellent working age, it is rare indeed to find that the talent of discovering new truths has been formed and developed so late in life. A major part of the great steps in science have been taken at even a much earlier period.

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[1] *The Origin and Progress of the Mechanical Inventions of James Watt.* 3 vols. 1855.

(330.) His eminent services as an expositor of science.

That Robison possessed all the elements of an original thinker we shall presently endeavour to show; but had his excellences consisted alone in those we have specified, he would have been a person eminently useful in forwarding the march of science. In fact, a few more such authors in every generation would be cheaply purchased by the postponement of some second-rate discoveries. Men—and we include men of science—are in too great a hurry to push on (actuated often by a morbid love of praise) to acquire something they may call their own, whilst they are little acquainted with the important contributions of their rivals in the race of fame, and of the predecessors to whom they really owe so much of what they may choose to consider their peculiar property. To methodize knowledge from time to time—to present discoveries in a form different from that in which they were first published, and thus connect them with what is already known and what remains to be clearly proved—these are real services to science which contribute in a very essential manner to its progress. Robison was a teacher, not only to the youth of his native country, but to the men of science and of practice of all countries, and of many succeeding years.

(331.) His early life and friendship with Watt.

JOHN ROBISON was born in 1739, entered the University of Glasgow at the early age of eleven, and graduated at seventeen. His early tastes were directed towards Natural Philosophy. He studied Mathematics (as in after life) chiefly with reference to its applications. Whilst at Glasgow he formed the intimate acquaintance of James Watt, then a practical instrument maker. In a passage of a private paper, published first in Arago's *Eloge of Watt*,[1] Robison, with his characteristic generosity, describes his mortification when "yet a young student" at finding him much his superior in mathematical and mechanical knowledge; but M. Arago has omitted to state that Watt was, *at least*, three years the senior, which at such an age, and on such subjects, might make all the difference between a beginner and a proficient. But the truth is, that with a rarely generous rivalry in excellence, each esteemed the other most; for we find Watt bearing a similar testimony to the superiority of his friend and junior: "I was happy to find in him [Robison] a person who was so much better informed on mathematical and philosophical subjects than I was."[2] It was by Robison that Watt had his attention first directed to the steam-engine; their correspondence appears to have been frequent during their joint lives; and near the close of his life Watt acknowledged "his obligations to him for very much information and occasional assistance in his pursuits;" and in the Edinburgh professor he found not only the zealous defender before a court of law of his rights as an inventor, but also the first who expounded methodically the principles and details of the steam-engine in a manner which, at least until lately, had not been superseded.

(332.) His adventures;

In 1758 he left Glasgow, and the following year he went to sea as tutor to a son of Admiral Knowles. His life in a man-of-war, during which he saw some active service in Canada, was favourable to the development of his practical turn of mind, and doubtless gave him an interest in seamanship, naval architecture, and other subjects, which he afterwards turned to good account; and a subsequent expedition to Jamaica, for the trial of Harrison's Timekeeper, exercised him in some of the practical parts of astronomy. He returned, however, to Glasgow in 1761, and attached himself with such success to the study of Chemistry under Dr Black that he taught the Chemical Class in the university for several sessions.[3] But his active life was not at an end. In 1770 he accompanied his first patron, Admiral Knowles, to Russia, and for some years was employed, first as his secretary, superintending improvements in the marine establishment, and afterwards as professor of Mathematics in the naval school of Cronstadt. He spoke and wrote the Russian language with facility,[4] and performed his duties to the satisfaction of all. But in 1774 he could not resist the honourable invitation which he received to fill the chair of Natural Philosophy in the University of Edinburgh, where he spent the remainder of his life, which terminated in January 1805, amidst incessant literary occupation, even when repeated attacks of a painful disorder had prevented him from personally continuing his lectures.

and his appointment to the University of Edinburgh.

(333.) Character of his articles in the *Encyclopædia Britannica*.

This brief sketch[5] of a career rather unusual for a man of science throws light upon Robison's peculiar merits. He had extensive, and then uncommon, opportunities of acquiring information, of seeing various countries, and of noticing their physical peculiarities; of being introduced to their society and literature;

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[1] And since, *in extenso*, in *Muirhead's Mechanical Inventions of James Watt*, vol. i., p. xli.

[2] *Ibid.*, vol. ii., p. 293.

[3] The MS. of these lectures, written with curious care, but with the use of continual abbreviations of the larger words for the sake of compression, is now in my possession, having been given to me by his son, the late Sir John Robison. I have also many others of his MSS., which for the most part seem to have been printed in some form or other. Dr Robison was an indefatigable penman, and wrote and re-wrote his lectures with great labour. He also made elaborate analyses of his reading, but the bad habit of contracting words remained with him through life.

[4] The private marks on his MSS. are often in the Russian character.

[5] A much fuller one will be found in Playfair's Works, vol. iv.

of taking part in the actual execution of scientific designs; of studying foreign languages; and of methodizing his knowledge for the purposes of instruction. Every one of these influences may be clearly traced in his writings, which will challenge comparison with those of any English writer, except perhaps Dr Thomas Young, for variety and fulness of information, and for the general soundness and strongly practical character of the mechanical knowledge with which they abound. They would also doubtless have appeared to far greater advantage had they been the product of his most vigorous days; but he was little known as a writer until the year 1793, when he commenced a series of important contributions to the *Encyclopædia Britannica*, embracing at least forty-six articles, all scientific, some of great length and elaboration, which were published during the succeeding eight years, a period when he was seriously afflicted with chronic disease. They embraced disquisitions on general philosophy, as in the articles Philosophy and Physics; of strict science, as in Astronomy, Dynamics, Projectiles, Pneumatics; of the more experimental sciences, as in Magnetism, Electricity, Sound; of the art of music (with which he was practically conversant), in Temperament, Piano, &c.;—but his great strength lay in the articles in which just mechanical principles were applied successfully, and often with marked originality, to practice, as in Arch, Roof, Carpentry, and Strength of Materials; Resistance, Rivers, and Waterworks; Seamanship, Steam and Steam-Engine; Machinery, Telescope, and Watchwork.

(334.) His *Mechanical Philosophy.* The last-named articles (most of which have been collected in a compilation, edited by Sir David Brewster, in four thick volumes, entitled *Robison's Mechanical Philosophy*) constitute a body of knowledge in civil engineering which has not yet been surpassed in clear exposition of physical principles and their application—in the extensive acquaintance it shows with the details of practice—and in proofs of elaborate and impartial study of authors, both British and foreign, on the subjects of which it treats. Several of these articles have been resorted to by the most accomplished engineers of our own time as stores of sound experience, and they have been lavishly borrowed from by some writers on similar subjects, occasionally without acknowledgment. The original matter which they contain is not always easily separated from that which is compiled. In every instance Dr Robison lays claim to less than his own share, and is so scrupulous in quoting the names of other authors, that he has unquestionably received less reputation from these Essays than he deserves. He writes like a man who has himself used the saw and hammer, who has had the responsibility of success or failure, who might have been called upon for a scientific opinion (of far more weight than what generally goes by the name) on almost any practical subject upon which he might have been consulted; and that not merely in its general outlines, but in its strictest details; not only the design for a roof or a centre, but the scantling of the timber to be used; the minutiæ of a pump or hot-air stove; the curvatures of an achromatic object-glass; the temperament of a piano; or the angle for the pallets of an escapement. In such matters nothing important either in the theory or the practice of his times escaped him. His opinions were very generally formed on original considerations, supported by experiments equally well devised and carried out. His method of finding mechanically the relation between the intrados and extrados of a properly balanced arch by means of suspended pieces of chain is as ingenious as it is elementary; but his observations on the manner in which stone arches, when overloaded, break up, established on direct observation and experiment, unquestionably gave a just foundation to the theory of masonry, till then so generally and erroneously treated of by mathematicians with the preposterous abstraction of the forces of friction and cohesion, the action of which in many instances vastly exceeds the direct effect of gravity.

Sound practical views.

(335.) Writings on electricity and magnetism. But on this we must not dwell. Robison's articles on Electricity and Magnetism are deserving of nearly equal praise with reference to the state of knowledge of the time. Probably there was not one author of merit on these subjects, whatever his country or language, whose works he had not laboriously consulted and analysed the conclusions; whilst a multitude of ingenious experiments give evidence of the skill and patience of the writer. To Dr Robison we are, indeed, indebted for the *approximate* knowledge of the primary law of electric attractions and repulsions; for a careful consideration of those beautiful curves formed by iron filings round magnets,[1] to which such an enlarged importance has since been given by the beautiful generalizations of Mr Faraday; and I believe likewise for the first suggestion of combining the voltaic elements in a *pile* or column.[2] Dr Robison, though for many years secretary of the Royal Society of Edinburgh, published little in its Transactions, and almost nothing, so far as I am aware, in any periodical work. Hence his admirable adaptations of experiments were little known beyond his own class and friendly circle.

(336.) His extensive reading and mathematical acquirements. Of his more abstract mathematical writings we need say little. He was thoroughly acquainted with the works and methods of Newton, and with nearly all those of the same school, particularly of Boscovich. He laboured incessantly to reduce the demonstrations of the higher mechanics and astronomy to their simplest and most geometrical elements. But the result (as might have been foreseen) was in many cases a wearisome prolixity; and originality could not be expected in these departments without applying the continental improvements in analysis: not that Dr Robison overlooked these; but he took little pleasure in them; and as regards Physical Astronomy he adhered to the older methods. Having been so long at St Petersburg, the writings of Euler must have been familiar to him, as indeed they evidently were as far as regards all subjects connected with mechanics: he justly, however, considered Euler as a superficial natural philosopher, though an incomparable mathematician.

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[1] Indirectly we owe to him also the first exact determination of the mathematical properties of these curves, made at his request by Mr Playfair.—*Robison's Mech. Phil.*, iv. 350.

[2] See the Fifth Dissertation (by Sir John Leslie), p. 739.

(337.) Robison as a lecturer. As a lecturer in his own department, Robison was the most eminent of his time, at least in Britain. That his courses were not considered *popular* will easily be understood from a slight inspection of his writings. The demonstrations were long and copious, but too rapidly delivered. "The singular felicity of his own apprehension," says Mr Playfair, "made him judge too favourably of the same power in others." The lectures must have abounded in practical details, which ordinary students rarely appreciate; and they were deficient in experiments, which unquestionably arose from no want of the ingenuity necessary either to invent or execute them. On the other hand, the effect of his discourses was greatly enhanced by his striking and energetic delivery, and by the stores of his memory, which often recalled the incidents of the stirring life in which he had once been engaged; and to the more thoughtful and philosophic they were rendered at once attractive and elevating in no ordinary degree by the strain of fervent thought by which they were accompanied, and the impress which they frequently bore of the pure morality and exalted piety of their author.[1]

(338.) His philosophical character. Apart from his local usefulness as a professor, we regard Dr Robison's place in science as eminent chiefly on account of the sagacity with which he applied knowledge to practice, and analysed complicated effects of force as manifested in engineering constructions. This he did so ably as to guide future practice, and to reflect much light on the theory of solids more or less elastic and tenacious, and subject to the intricate strains which gravity produces. The difficulty and merit of these investigations will best be gathered from the slow progress of his successors in the same field. The criticism with which his writings abound on the theories of even his more celebrated contemporaries and predecessors show remarkable acuteness, patience, and independence of thought. We may perhaps sometimes think him prejudiced, but his decisions are never uttered without an elaborate statement of reasons, nor ever sullied by the suggestions of jealousy or self-conceit. Had he been an accomplished analyst he must have been less distinguished in the equally important walk in which he stood pre-eminent. The limits of human life and faculties prevents universal attainment, but he was surely no mean philosopher of whom the sexagenarian James Watt could say, "*He was a man of the clearest head and the most science of anybody I have known.*"[2]

(339.) Coulomb on friction and passive strength. Amongst the contemporaries of Robison was one whose acquirements were in many respects very similar to his own, and who contributed, in a degree second to no other philosopher of his day, to promote sound views in the very same branches of science. Charles-Augustin Coulomb (born 1736, died 1806) was, like Robison, addicted through life to practical enquiries, and was intimately acquainted with all the details of the civil engineering of his day. To him we owe a correct knowledge of the laws of friction in most ordinary cases, and the right application of them to the theory of machines, and to that of the stability of structures. In a very remarkable paper, published in 1776, he analysed, from the basis both of theory and experiment, the manner in which columns of masonry give way under longitudinal pressure; not, as had previously been supposed, by flexure under the imposed weight, like a steel spring or a rod of deal, but by the sliding of one portion of the column over another, at an angle determined by the cohesion of the stone, and capable of being reduced to a problem of maxima and minima. This important principle is now known to apply to wrought and cast iron, and many other substances.

(340.) On torsion. One of Coulomb's happiest investigations was on the force of torsion, or the resistance of wires to twisting; which he showed to vary directly with the angle of torsion, inversely as the length of the wire, and directly as the square of its section. These mechanical principles he applied with address to determine the viscosity of fluids, and with still more consummate skill and success to the measurement of electrical and magnetical forces by the construction of a Torsion Balance, similar in principle but anterior to that employed by Michell and Cavendish for estimating the force of gravity.

(341.) His researches resembled Robison's. Coulomb's researches on electricity (which have been only partially published) will be made the subject of discussion in another chapter of this Dissertation; they were the most sustained and elaborate of his investigations, and display very considerable mathematical resources. In this respect he had a superiority over Robison, who, as we have seen, cultivated precisely the same branches of science which gave distinction to the career of Coulomb. When we compare the two philosophers, we find that the former was the more discursive reasoner and experimenter, and was diverted, perhaps by the copiousness of his erudition, and the attention with which he studied the works of others, from doing full justice to his own original powers. The latter excelled as a mathematician; he concentrated his efforts more methodically, and displayed the results to the world (so far as they were published) in a more consecutive and lucid form. In uprightness of character and high morality, the two philosophers bore a marked resemblance. They were both sufferers from bad health, and they died within about a year of each other, at nearly the same age.

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[1] See *Dr Chalmers' Life*, vol. i. That great man had a peculiar veneration for Dr Robison, and is understood to have received impressions from attending his lectures which materially influenced his future life.

[2] *Mechanical Inventions of James Watt*, ii., p. 290.

§ 3. Thomas Young—*Strength of Materials, and Art of Construction (continued).*—Telford—*Introduction of Iron into permanent Structures. Suspension Bridges.*—Tredgold; Mr Hodgkinson; M. Navier.—Mr Robert Stephenson—*Tubular Bridges.*

(342.) Difficulty and importance of the enquiry into the mechanical properties of solids.

It is a circumstance not uninstructive as to the progress and achievements of science, that the greatest modern philosopher who preceded Newton—Galileo—and one of the most eminent, if not the most eminent, of his successors—Young—should have laboured with minute and practical care, and with corresponding success, on a subject apparently so humble and mechanical as the Strength of Materials, and the Resistance of Beams to fracture. Newton himself condescended to swing pendulums, and to observe the collisions of elastic worsted balls. It is sufficient here to advert to the exceeding interest of enquiries which throw so much light upon the internal constitution of bodies, and in some instances intimately connect them with the laws of vibration of elastic media, to which so much of Modern Physics is intimately allied.

(343.) Progress during the eighteenth century.

The eighteenth century was in this, as in so many other departments of science, sluggish and mechanical, or else abstract and ultra-geometrical. The learned labours of Euler and the Bernouillis on elastic curves, and the strength of pillars, were for the most part elegant mathematical amusements, and with the exception of the experiments of Musschenbroek in the earlier half of the century, and the skilful but more limited researches of Coulomb at its close, little valuable in the way of precise theory or of accurate data derived from practice had been added to this important branch of mechanical engineering.

(344.) Thomas Young.

Robison, indeed, with the peculiar tact and skill which I have already ascribed to him, wrote several papers (contributed to an early edition of the *Encyclopædia Britannica*, and printed in his collected works) full of acute observation and reasoning, adapted to the imperfect experiments of his time, and connected by sound scientific deductions, which are still well worthy of careful perusal; but it was to the penetration of Dr Thomas Young,[1] who partook strongly of Robison's mechanical tastes, whilst he surpassed him in facility of mathematical resource, that we owe a great revision of the doctrine of the strength of materials. In the "Syllabus of Lectures" (1802), into which he condensed, in a manner peculiar to himself, an incredible amount of positive knowledge; in the Lectures themselves (1806), with the admirable "Catalogue of References;" and in the articles on "Bridges," and the supplementary propositions on "Carpentry," which he contributed to this Encyclopædia—we find (stated, as usual, not without some obscurity) a multitude of theorems and problems embracing the whole principles of construction, and based upon mechanical laws and the most probable interpretation of experiments.

(345.) Application of force to solids.—Extension.

Modulus of Elasticity.

The forces tending to alter the figure or dimensions of substances usually called *solid* may be thus classified: (1.) Extending forces, or such as produce elongation in a body when applied in a direct manner. (2.) Compressive forces. (3.) Force producing *detrusion*, or the slipping of one portion of the substance over another. (4.) Force producing flexure. (5.) Torsion or twisting force. The resistance of bodies to extension was examined by Hooke and Gravesande, and is held to be directly as the area of section of the body, and to increase directly as the amount of elongation produced, at least within certain limits. The measure of this resistance Young termed (not very happily) *Modulus of Elasticity*, expressing the force required to produce unit of elongation (or to double the length) of a prism of the substance under experiment. This quantity may be measured either by the length of a depending prism of the substance which would produce the requisite strain, or more simply by the strain expressed in pounds or tons, which, *supposing the elongations to increase without limit as the extending forces*, would double the length of the prism under experiment. Thus, in round numbers, a bar of wrought iron an inch square will be extended $\frac{1}{10000}$ part by a pressure of one ton—hence the modulus of elasticity is about 10,000 tons. The elasticity of wrought iron remains perfect to about half the breaking weight, after which the elongations appear to double for each addition of about $\frac{1}{10}$ or $\frac{1}{12}$ of the breaking weight. Thus, in a recent experiment by Mr Edwin Clark, a bar of wrought iron, one inch square and ten feet long, extended $\frac{8}{100000}$ of its length for every ton of weight up to 12 tons, from which point the extensions nearly doubled successively for every two tons of load, and the bar was finally torn asunder by 23 tons.

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[1] I reserve to the chapter on Optics a fuller account of Young and his writings.

(346.) Compressing force. The *compression* of bodies proceeds (like the extension) at first uniformly with the load. Some bodies resist compression more than extension (as cast iron); some the reverse (as wrought iron). Substances give way under compression after different fashions. Hard bodies divide into prisms parallel to the compressing force; slender elastic bodies bend laterally; soft bodies bulge horizontally; bodies of a medium hardness divide into wedges, and the surfaces slide along the plane of spontaneous fissure. Detrusion. *Detrusion* marks more particularly the mode of giving way by the sliding of surfaces in the interior of solids. Though seldom due to force directly applied, it is an important element in most cases of the rupture of semiductile solids.

(347.) Flexure of beams. The force of *flexure* is that by which the resistance of the greater number of solids is most easily overcome, but which it is of most importance to resist; as when a beam is fastened by one end into a wall, and loaded at the other, or when it spans a horizontal space. It had not escaped the notice of James Bernouilli, Duhamel, and other writers of the earlier part of the 17th century, that the fibres on the concave side of a loaded beam are in a state of *compression* and not of extension, and that there is therefore a point, or rather a line, in every beam, in which the fibres are neither extended nor compressed. But the clear modification of the theory prevalent in the time of Leibnitz and Marriotte which this consideration introduced, was probably first developed by Coulomb, Robison, and Young, who in their respective publications insisted upon it with great judgment; and it is difficult to overrate its importance in mechanical engineering, although the first great canon of Galileo remains still true, that the ultimate strength of a solid rectangular beam varies as the breadth and as the square of the depth. The writings of Young and Robison did not immediately attract the attention of practical men, and Coulomb, who was by far the ablest French experimenter on subjects of mixed mechanics, seems to have done less on the theory of strains producing flexure than in the case of torsion, which he studied with so much success, and applied to such excellent purpose. Nevertheless in his memoir on the Resistance of Masonry, in the 7th vol. of the "*Memoires Presentés*" (1776), he had already laid down very clearly the effect of compression on a beam.[1] It is, however, to Young that we owe the application of these principles in unfolding their legitimate consequences. In a series of remarkable propositions contained in the writings I have quoted (344), he assigns numerical relations between the flexure of a beam under almost every supposable circumstance, and the resistance of the material to direct strains. These results have been extensively used by all subsequent writers. They are not equally verified in all classes of substances. This, however, is not wonderful; flexure is not due to direct compressive and extending strains alone; *deformation* may take place in a solid without appreciable change of density, thus giving rise to some of the nicest questions in molecular physics.

(348.) Torsion. The laws of *Torsion*, as laid down by Coulomb, have been mentioned in the last section (340).

(349.) Young's mechanical writings. The mathematical investigations of Young on mechanical problems were conducted with bold directness and in defiance of the generalizing methods and symmetrical notation of foreign writers on such subjects. But his pre-eminent sagacity in laying hold on the salient points of the questions he discussed, and in conducting his argument to a practical conclusion, was unequalled, and deserves imitation.[2]

(350.) General use of wrought iron. A great revival in the study of the properties of elastic matter, as regards strength, took place about the year 1820, probably in consequence of the introduction of wrought iron into the construction of suspension bridges, which has been attended with important results.

(351.) Telford; suspension bridges. THOMAS TELFORD, though neither the contriver of suspension bridges, nor the introducer of them into Britain,[3] deserves notice from the superior boldness and solidity of the noblest work of the kind which has yet been executed—the Menai Bridge. Telford (and the same may be said of his contemporary Rennie) was more distinguished as a man of judgment, integrity, and experience, than as eminently original or philosophical. In this respect both yield to Smeaton, who, with Watt, was the founder (each in his own department) of modern engineering. But the beautiful and truly workmanlike structure of the Menai Bridge inaugurated the era of the extensive introduction of that admirable material, WROUGHT IRON, into great permanent structures exposed to heavy strains. Cast iron had been used much earlier, as in the bridge erected at Colebrookdale in 1777 by Mr Derby, and in the very beautiful arch at Sunderland, which dates from 1796. The span of the Menai Bridge is 580 feet, the whole quantity of iron used was 2186 tons, the transverse section of the suspending chains or bars was 260 square inches, supporting a strain of 1094½ tons. This was a work quite unexampled at the time of its erection (1826), and showed a sagacious confidence in the employment of a material then comparatively little trusted.

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[1] Reprinted in the *Théorie des Machines Simples*, Paris, 1821.

[2] A copious selection from Young's mechanical writings may be found in his *Miscell. Works* edited by Dr Peacock, vol. ii.

[3] Captain Samuel Brown erected the first considerable chain bridge in this country across the Tweed in 1819.

(352.) *Data* of resistance.

Tredgold, Barlow, and Hodgkinson.

Telford never made *extensive* experiments on the resistance of solids. Some special ones were indeed made under his direction on wrought iron in particular, but in general he seems to have relied upon the old ones of Musschenbroek and Buffon. The two persons who first in recent times vigorously applied themselves to the practical determination of the data of resistance so long deficient, were Tredgold, a private engineer, and Professor Barlow of Woolwich. The data they obtained have since been generally used, not only in this, but in other countries. Tredgold's works (on Carpentry, Strength of Timber, &c.) show a very great aptitude in applying the results of science to practice, and an acquaintance with both which is rarely attained. Mr Eaton Hodgkinson has made many valuable additions to Tredgold's work, and has contributed an excellent paper on the strength of pillars to the *Philosophical Transactions* (1840.)

(353.) Geometry of the catenary.

To Mr Hodgkinson we are also indebted for a useful investigation (in the *Manchester Transactions*) into the figure assumed by the chains of suspension bridges. The elegant properties of the simple or geometrical catenary were fully investigated a century and a half since by the Bernouillis and by David Gregory, but the application of suspended structures of immense weight to purposes of utility suggested new problems. Amongst these, perhaps the most interesting was the *catenary of uniform strength*, in which the section of the suspending chains is made everywhere proportional to the strain which they have to resist at that particular point. Its equation was investigated by Mr Davies Gilbert in 1826. An elegant and valuable contribution to the geometry of catenarian curves was made by the late Professor Wallace of Edinburgh,[1] with particular application to curves of equilibration for bridges of masonry after the ingenious manner of Robison mentioned in Art. (334).

(354.) M. Navier.

In connection with suspension bridges, and also with researches on the yielding of elastic materials, we must record the name of M. Navier, a very eminent French engineer and writer on practical and theoretical mechanics. His work on suspension bridges (1823) is one of the earliest and best. He is also well known for his physico-mathematical researches on the yielding of elastic solids to pressure under given circumstances, in the course of which he came into collision with Poisson, who gave a somewhat different theory. The subject is one of extreme difficulty, owing to our ignorance of the molecular constitution of bodies; and it is believed that all these investigations were so far erroneous that they were based upon the assumption of a *single* constant to represent the resistance of bodies to change of form and dimension. These (form and dimension) are two very different things, and require distinct treatment.[2] British mathematicians have lately paid much attention to these enquiries, with the prospect of a solid improvement in engineering theories.[3]

(355.) Mr Robert Stephenson.

The art of bridging over great spaces has been pushed, by the requirements of the railway system, to an astonishing extent, and under circumstances of peculiar difficulty. I shall connect these improvements with the name of Mr Robert Stephenson, the inventor of the Tubular Bridge, a work which, in its very simplicity, is a triumph of art, and being nothing more than a *hollow beam* of somewhat peculiar construction, supported at the ends, it is an admirable instance of a structure of which the stability may be easily reduced to calculation.

(356.) Wooden bridges in Switzerland and America.

The wooden bridges of Switzerland were for a long time unequalled as skilful works of carpentry. During the last century the Rhine at Schaffhausen was crossed by two spans of 171 and 193 feet. At Trenton, in America, the river Delaware is crossed by a wooden bridge, of which one arch is 200 feet in span. It is on the *bow* principle, an elastic wooden arch, convex upwards, being skilfully braced and united to a level roadway passing through the spring of the arches. The American lattice bridge, very simply and skilfully contrived, has great firmness, owing to the depth of the framing, and exercises no horizontal thrust on the piers. The widest spanned wooden bridge in the world, 340 feet, across the Schuylkill, at Philadelphia, designed by Wernwag, combines the bow and lattice principle.

(357.) The tubular bridge.

In these we might see foreshadowed in some faint degree the principle of the Tubular Bridge, the greatest discovery in construction of our day. But in reality the idea of it arose from a different consideration.

(358.) Railway girder-bridges.

During the first ten or fifteen years of railway experience, engineers had gradually acquired a correct perception of the manner in which cast and wrought iron may most effectually and economically be formed into girders or beams supported at the ends, and adapted for sustaining enormous loads. Such beams were constructed, often of single castings, so as to include three portions; an upper *flange*, a lower *flange*, and a *web*, or thinner vertical plate connecting the two. The relative section of the upper and lower flange was made to vary with the material. In cast iron, which yields far more easily to tensile than to compressive strains, the lower flange should be almost incomparably greater than the upper; in wrought iron a slight predominance should be given to the upper flange for the converse reason.

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[1] *Edinburgh Transactions*, vol. xiv.

[2] About twenty years ago, the present writer showed that India rubber, which possesses to such a remarkable extent the quality which may be termed *cubical flexibility*, is yet scarcely at all compressible—in fact, just as much as water, and no more. Though not otherwise published, he has been in the habit of demonstrating this in his annual course of lectures.

[3] Professor Stokes in *Cambridge Transactions*, vol. viii.; Mr Clerk Maxwell in *Edinburgh Transactions*, vol. xx. Mr M. Rankine in *Cambridge and Dublin Math. Journal* for 1851 and 1852. Experimental data are still deficient; but M. Wertheim has lately published some valuable ones (which are still in progress) in the *Annales de Chimie*.

(359.) The idea of the tubular bridge derived from them.

Hence it will be easily understood how, when Mr Robert Stephenson was desired to construct a railway bridge across the Menai Strait,—subject to the onerous condition imposed by the Admiralty, that it should (even at the abutments) be without lateral struts or diagonal pieces below the roadway,—he should have entertained the idea of a gigantic girder with a top and bottom flange of proportionate extent, with a deep *web* uniting them, or rather of two such girders placed side by side, thus forming square tubes, of which the lower flanges should constitute the bottom, the upper flanges the top, and the two *webs* the sides.

(360.) Progress of the invention.

It is not for me in this place to explain how, step by step, the idea of a tubular bridge of wrought iron assumed the practical shape, now to be seen at Conway, and near Bangor, in North Wales. It is unfortunately notorious that there has existed an unhappy rivalry as to the share of merit due to the several persons who of necessity were jointly concerned in the completion even of the design of these astonishing works. Unfortunately for Mr Stephenson's tranquillity, the tremendous responsibility of this novel, gigantic, and costly experiment, was thrown upon him during the very height of the commercial and engineering excitement (not unjustly called *mania*) which prevailed in 1845 and 1846, on the subject of railway projects. Instead of the uninterrupted leisure which he required to superintend his preliminary experiments, to consider his plans, and perform his calculations, Mr Stephenson, as well as every other engineer of eminence was at that time engaged all day and a great part of the night in the unparalleled worry of Parliamentary contests. As a matter of course, much was trusted to able, confidential, and highly paid assistants. The experiments on models of different forms, which alone cost many thousand pounds, could not all be conducted in the presence of the chief engineer. Yet he alone was responsible for the failure or success of the plan.

(361.) The cellular top.

The comparatively great strength of tubes was a fact known from the time of Galileo. Their defect was a liability to crumple or pucker. Round, oval, and rectangular tubes were tried, and the last (Mr Stephenson's original conception) were, as might be supposed, found to be stronger than the other two. When supported at the ends, and loaded in the middle, model tubes of this form invariably gave way at the top. How to strengthen the top against compressive strains was the question. The excessive stiffness of corrugated iron and zinc plates (long previously used for roofs) came to the engineer's assistance. A combination of two longitudinally corrugated or *goffered* wrought-iron plates running along the top of the model, and forming long and nearly cylindrical cells, was found to give the required stiffness with the least increase of weight. Ultimately a square arrangement of cells was adopted, principally to give facility for painting and repair. The tubes were hindered from *racking* by means of numerous wrought-iron frames employed to stiffen them, whose section resembled the letter T, and which were called T irons. Suitable diaphragms were also inserted at short distances along the tubes. The widest spaces to be spanned at the Menai Strait were 460 feet, there being two intervals of this width, and two of 230 feet. The tubes are 30 feet high and 14 broad, containing a transverse section of about 1500 square inches of wrought iron. The weight of one principal tube is about 1450 tons, and its strength, measured by the breaking load at the centre, above 2300 tons. This last number is calculated from the experiments on the breaking weight of models, one of which was on no less than a sixth of the true scale. The boiler plates, of which the tubes are composed, are united by mechanical pressure by means of hot rivets; and it may safely be affirmed that without this ingenious and perfect method of combination (which is due to Mr Fairbairn), the structure would have been impossible.

Dimensions and strength of the bridge.

(362.) Its complete success.

The success of this astonishing piece of engineering has been complete; the stiffness of the tubes, whether under constant pressure or during the rapid transit of trains, is almost incredibly great.

(363.) Mr Stephenson the responsible inventor; assisted by Messrs Fairbairn and Hodgkinson.

To Mr Robert Stephenson is clearly due the credit of undertaking, on his sole responsibility, a project of equal boldness and novelty, and of contriving, not perhaps in every detail, but in its totality, the means by which so signal a triumph of art and of science was carried into effect, an honour to his own age, and a lesson to posterity. To Mr Fairbairn and Mr Hodgkinson, his assistants, selected by himself, much praise is also due for the manner in which the experiments were managed, and the principles established by these educed. Mr Fairbairn, a practical engineer of Manchester, well known for his experience and sagacity, gave to Mr Stephenson, as a matter of honour, the full benefit of both; and his confidence in the result helped no doubt to sustain the manly courage of his principal amidst a storm of opposition. Mr Hodgkinson, well known for his able enquiries into the strength of pillars and girders of different forms, conducted the mathematical enquiries, and determined the relative strengths of the models. His confidence in the result was less encouraging than that of his coadjutor, which serves to show the greatness of the responsibility of the engineer-in-chief. As neither Mr Fairbairn nor Mr Hodgkinson could have incurred any just blame had the vast structure when on the eve of completion doubled up under its own weight, and blocked up, perhaps for ever, the navigation of half the Menai Strait, so neither can they possibly claim more than a subordinate share in the success of the undertaking.[1]

(364.) Commission on railway bridges. I shall here only refer to the work of Mr Edwin Clark, the resident engineer of the Britannia Bridge, for farther details of its principles and construction, and to the report of a royal commission (published in 1849) on the application of iron to railway structures, for many curious researches connected with the subject of this section. In particular, we find a theoretical and practical solution of the very delicate problem of the influence of the speed of passing loads on the deflection of bridges, to which Professors Willis and Stokes, and Colonel James, R.E., are contributors.

(365.) Other works of Mr Stephenson. Mr Robert Stephenson is the son of Mr George Stephenson, who will be mentioned in a succeeding section. He was born in 1803; educated (in part) at the University of Edinburgh, under Leslie, Hope, and Jameson; he long occupied the chief position in the locomotive factory established by his father at Newcastle, having in the first place constructed under his direction the celebrated "Rocket" engine which gained the prize at the opening of the Liverpool and Manchester railway. To his own exertions, both before and after that period, the locomotive owes much of its present perfection. He surveyed and principally carried through the London and Birmingham railway, the second great line in the kingdom; and he has been engaged in a large proportion of the most remarkable engineering works connected with railways, both in this country and abroad. He has personally superintended the construction of railways amidst the blowing sands of Egypt, and in Norway with its heavy winter snows and deeply frozen soil. His high personal character, both for skill and integrity, has everywhere procured him the respect and confidence of his profession and of the public.

§ 4. Brunel.—*Self-acting Machinery.—The Thames Tunnel.*—Mr Babbage's *Calculating Engines.*

(366.) Marc Isambart Brunel. Sir Marc Isambart Brunel, born at Hacqueville in Normandy on the 25th April 1769, was one of the most inventive mechanicians and engineers of his day. As his genius gave a strong impression to contemporary art, we associate his name with the progress of civil engineering in the earlier part of the present century, particularly in connection with mechanism. Like most of his eminent coevals in the same profession, he had not the benefit of a scientific education; but he more than most of them supplied its defects by a singular capacity for correct induction and by great mechanical ingenuity. Though a native of France, it was in Great Britain that his talents were to find their full scope, and it became his thoroughly adopted country.

(367.) His early history. Disgusted by the horrors of the first revolution, he quitted France in 1793 in the capacity of a common sailor, a position far below that which either his birth or his intellect entitled him to hold, yet in which he made himself remarked by his excellent disposition and mental superiority. His destination was New York, where in 1794 he commenced his career as a civil engineer, his boyish tastes having already indicated this as his natural calling. He executed some considerable works, and planned many more; it is stated that he there devised the essential parts of his block machinery. About 1799 he decided on settling in England.

(368.) Employed by the English government. It is probable that his talents and ingenuity alone recommended him to a government employment at a time when the mere fact of his being a Frenchman must have acted as a powerful obstacle to his success. Those who recollect the vivacity and bright intelligence of even his later years, will understand that in his more active days it must have been difficult to refuse Brunel at least a hearing. And it is to the credit of Lord Spencer, then one of the Lords of the Admiralty, and of General Sir Samuel Bentham, inspector of naval works, that Brunel was engaged in 1802 to superintend the erection of his celebrated block machinery.

(369.) Self-acting machinery. The invention of self-acting machinery to supersede the work of artisans was of course not new. The saw-mill and the spinning-jenny were already in use, but the invention of Brunel was not less important as creating an epoch in art. Not only is it possible to execute in a comparatively short time, and with a prodigious economy, objects such as blocks and pulleys, which are required in vast numbers and precisely alike, but the nicety and accuracy of the manufacture is thereby increased, and owing to the facility with which inanimate force may be concentrated on machinery, works which transcend the power of unaided muscular labour are as surely and exactly executed as those of smaller dimensions. For example, by no enlargement of the common turning-lathe would it be possible to construct an accurately turned iron steam-cylinder 8 feet or more in diameter, which is yet readily executed under the direction of a very ordinary workman by means of steam power and self-acting machinery.

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[1] It has been alleged that Mr Stephenson's original proposal to allow the suspension chains (which were primarily intended to be used in putting together the tubes in their final positions) to remain in aid of the rigidity of the structure, manifested a want of confidence in his own great idea. But a dispassionate consideration of his evidence before the committee of the House of Commons would alone clearly show (independent of Mr Stephenson's declarations on the subject) that he was forced into the admission that the chains might give an ulterior guarantee against miscarriage of the whole plan, simply to save the bill from being thrown out by the not unnatural incredulity of those to whom a proposal so new, so gigantic, and affecting the lives of so many persons, as well as so great pecuniary and other interests, was for the first time and suddenly proposed. Besides this, even his own coadjutors did not all entirely support him. Mr Hodgkinson, whose character for scientific knowledge carried great weight with the committee, recommended in his report the ultimate additional security of chains.

(370.) The block-machinery; The block-machinery at Portsmouth consists of a series of engines impelled by steam, and by means of which the materials of wood and metal employed in the construction of ships' blocks are reduced to exact forms in graduated sizes, and are finally put together with very little manual labour. These machines, with the exception of the turning-lathe and circular saw, were wholly new, and, it is stated, were devised in part by General Bentham, who gave to Brunel at least the benefit of his advice and previous experiments. In some of them we have the first germ of implements now used by every machine-maker in the kingdom; and the ingenuity of the movements, and the variety of effects produced, earned for this great invention a just celebrity. Such a beginning could not have been made without the aid of government. To construct the tools was an expensive and troublesome business, and to start the manufactory cost L.53,000, which was speedily saved by the economy of the process. In the course of a year 140,000 blocks of no less than 200 different patterns were produced, and the number of workmen was diminished in the proportion of about 11 to 1. As a reward, Mr Brunel received L.16,000, being two-thirds of the first year's saving, itself a sufficient proof that he was the *bona fide* inventor of this admirable apparatus, whatever hints he may have received from his immediate superior.

its results.

(371.) Gave an impulse to mechanics. So successful an experiment produced ultimately, though with characteristic slowness, its effect on the mercantile world; nearly twenty years elapsed before such a splendid example of ingenious economy and artistic precision was at all generally imitated. Yet before his death, Sir Marc Brunel saw the fruit of his ingenuity almost indefinitely multiplied in the workshops of London, Manchester, Glasgow, Newcastle, and Birmingham, and highly appreciated if less extensively imitated abroad.

(372.) Introduction of mechanism into workshops. The more we reflect on the comparative state of the arts now and a century ago, the more we shall find reason to estimate highly the introduction of correct and scientific ideas of machinery and of tools for constructing other machines and structures. It was, in fact, the necessary complement of the invention of the steam-engine. Watt contrived the mighty Heart which was to give a new impulse to social life, Brunel and others of the same stamp added limbs and muscles, whereby its energies were rendered thoroughly practical. The sixteenth, seventeenth, and part of the eighteenth centuries, had given to the world designs for countless mechanical contrivances, often highly original and ingenious. But many were grounded on fallacies, and others belong to the class of elaborate trifles. At that period the slide-rest of the turning-lathe, the planing machine, and the circular saw, were practically unknown; at least the two former, which are incomparably the most important inventions of their class, and which belong to no certain author, having almost imperceptibly come into use—the slide-rest about the end of the last century, the planing machine as lately as about 1820. The former of these readily forms surfaces of revolution with geometrical accuracy, the latter plane surfaces, and in either case the application to metals is most important. The circular saw and slide-rest form part of Brunel's series of machines, and he afterwards constructed the former on a very great scale for the manufacture of wooden veneers. To them he added the mortising machine, and these, it will be seen (together with the planing engine), form the staple of the magnificent and varied apparatus with which, driven by the gigantic power of steam, our mechanical factories are now so generally provided. We again repeat that the triumphs of art in which our generation glories, our railroads, our locomotives, our crystal palaces, and our steam navies, would have been impossible feats but for the improvement of tools and the substitution of steam for muscular power.

Slide-rest and planing machine.

(373.) The Thames Tunnel. Every one is, however, aware that Brunel owed his reputation to other achievements as well as his improvements of mechanical tools. The Thames Tunnel will ever be considered as his most arduous triumph. It is a structure of exquisite firmness laid in a quicksand. It will endure like the *cloacæ* of regal Rome, when the palace and the cathedral have crumbled to dust. Yet here also we perceive that it was Brunel's exquisite mechanical tact and ingenuity which enabled him to succeed. The problem of the tunnel is not one of balancing vaults; the statical conditions of stability are simple enough, and it was not in the solution of such that Brunel peculiarly excelled. The practical problem was to introduce a rigid tube of brick horizontally into the middle of a quaking mass of mud; and the solution was the invention of a tool which should enable men to make the excavation and to proceed with the building in safety. It was *the shield* which carried the tunnel under the Thames,—a moveable vertical frame of cast iron, provided with thirty-six cells, in each of which a man was placed with a pick to ex-

The *shield*.

cavate the area required for the construction of the tunnel. By a simple but most ingenious contrivance, every part of the face of unstable clay was firmly supported by boards which leaned upon the frame or shield, which, in its turn, pressed against the part of the brickwork of the tunnel already completed. Each workman could remove one or more of these small boards at pleasure, and excavate a short way into the yielding mass before him, then advance the boards and sustain the slippery face. When the whole face had thus undergone piecemeal excavation, the frame or shield was moved bodily forwards by powerful screws, and the bricklayers brought up the masonry behind, which was then beyond the reach of injury.

(374.) Completion of the tunnel. The idea of the shield was derived, it is stated, from a specimen in the arsenal at Chatham, showing the operations of a testaceous worm which bores under water, and which nature has provided with a protective covering. But the analogy is certainly indirect, since water could hardly retard the operations of such an animal. Repeated irruptions of the Thames several times *drowned* the work, which was as often abandoned and renewed, but every difficulty was met by fresh resources on the part of the engineer. The failure of funds was a far more serious obstacle, and government at last came to the aid of an undertaking of such consummate ingenuity that its completion was deemed due to the honour of the nation. The tunnel was commenced on the 2d March 1825, and finished 25th March 1843. Death of Brunel. Brunel survived the completion of his great work above six years, dying on the 12th December 1849, aged 81.

(375.) Variety of his works. We have not in this brief sketch glanced at one half of his ingenious projects and successful enterprizes. Scarcely any branch of his multiform profession but received some improvement at his hand. The discovery of the condensation of several gases in 1823, by Mr Faraday, suggested to Brunel their application as a moving power; and his want of success did not arise from any deficiency on his part of skill or forethought. He was one of the first to construct a roof of extreme lightness, somewhat resembling those now in use for railway stations. He erected a suspension bridge in the Isle of Bourbon on an original plan; and he pointed out with characteristic shrewdness how much of the stability of arches depends upon the cohesion of the parts, so that the vault may in some cases be entirely dispensed with.

(376.) It will be understood that we have selected Sir Marc Brunel as the representative of a class, the eminently *mechanical* engineers, a class now extensively multiplied, and amongst whom his son, Mr Brunel, occupies an eminent position.

(377.) Calculating machines of Mr Babbage. It cannot be expected in an essay like the present that I should enter into the details of the variety of mechanical inventions which have now become so numerous, and which have been marked by every gradation of originality and resource. But as illustrating a class of contrivances altogether different from those of Brunel, though like them tending to produce a great influence on the improvement of the mechanical arts, I will briefly refer to the Calculating Machines of Mr Babbage, which have at different times excited the interest of the public and of scientific men.

Mr Babbage was a fellow student at Cambridge with Sir John Herschel and Dean Peacock, and along with them he contributed by his writings and personal efforts to introduce into that university the improved Continental mathematics. A few years after leaving college he originated the plan of a machine for calculating tables by means of successive orders of differences, and having received for it in 1822 and the following year the support of the Astronomical and Royal Societies, and a grant of money from government, he proceeded to its execution. It is believed that Mr Babbage was the first who thought of employing mechanism for computing tables by means of differences; the machine was subsequently termed *the difference engine.* In the course of his proceedings Mr Babbage invented a mechanical notation (described in the *Philosophical Transactions* for 1826), intended to show the exact mutual relations of all the parts of any connected machine, however complex, at a given instant of time. He also made himself acquainted with the various machines used in the arts, with the tools used in constructing them, and with the details of the most improved workshops. Employing Mr Clements, a skilful mechanist, a portion of the calculating machine, very beautifully constructed, was brought into working order, and its success so far answered the expectations of its projector. But, notwithstanding several additional grants from government, the outlay on this most expensive kind of work soon exceeded them. The part actually constructed is now placed in the Museum of King's College, London; it employs numbers of nineteen digits, and effects summations by means of three orders of differences. Though only constituting a small part of the intended engine, it involves the principles of the whole. The inventor proposed to connect with it a printing apparatus, so that the engine should not only tabulate the numbers, but also print them beyond almost the possibility of error. (378.) *The difference engine.*

At this stage (1834) Mr Babbage contrived a machine of a far more comprehensive character, which he calls the Analytical Engine, extending the plan so as to develop algebraic quantities, and to tabulate the numerical value of complicated functions when one or more of the variables which they contain are made to alter their values. Had this engine been constructed, it would necessarily have superseded what had already been done. Government were not unnaturally startled by this new proposal, and as about the same time Mr Babbage's relations to (379.) *The analytical engine.*

Mr Clements were broken off, the difficulties of the affair became insurmountable, and the construction of either engine has for some years been in abeyance. The opinions of men of science are not unanimous as to the great practical importance of calculating tables by machinery, but the improvements of mechanical contrivance which the joint skill of Mr Babbage and Mr Clements introduced into engineering workshops are unquestionably of great importance to the arts. Though the details of Mr Babbage's plans have not been published, there can be no doubt that, whether economical or not as substitutions of machinery for human labour, they were devised with remarkable skill and ingenuity, and even on this account merit preservation.[1]

(380.) M.Scheutz' calculating engine. Recently (1855) attention has been directed in London to a simple and effective *Difference Engine* constructed and patented by M. Scheutz, confessedly on the principles of Mr Babbage, though without an acquaintance with his mechanical contrivances. The result is stated to be satisfactory. The engine deals with fifteen digits or figures, and with four orders of differences. Only eight figures are preserved in the result, the others being reserved to prevent errors arising from the accumulation of still lower digits omitted. The engine not only computes with facility and accuracy, but, by means of steel punches impressing lead, provides for the perpetuation of the numbers in the form of stereotyped plates. The workmanship of the whole requires no particular nicety of execution, is not liable to derangement, and can by scarcely any contingency produce inaccurate results.

(381.) Foreign writers on the theory of machines. Before closing this section, we may advert to improvements in the theory of machines by those who have regarded it rather from the geometrical side than from that of routine practice. Our French neighbours have been distinguished in this respect. Carnot and De Prony, MM. Hachette, Poncelet, and Morin, have been or are accomplished mechanists in this respect; and in the French repertories we must look for some of the earliest good scientific descriptions of machinery, even when of English invention.

(382.) English authors. In England, besides Mr Babbage, Professor Willis of Cambridge has shown a peculiar aptitude in this department, and has published a very valuable work on machinery, regarded in a strictly geometrical sense.[2] To Mr Moseley we are likewise indebted for some valuable contributions to the theory of engineering.

§ 5. Trevithick.—George Stephenson.—*The Locomotive Steam-Engine.—Rise and Progress of Railways.*—M. de Pambour *on Locomotives.*

(383.) The locomotive engine and railway. Of all the inventions which have powerfully affected the interests of mankind, none have been more slowly perfected, or can be less certainly traced to a single individual as the inventor, than those of the Locomotive engine and the Railway. These two great and essentially connected portions of the greatest mechanical and commercial effort of any age or country had their origin in obscurity. Each appeared several times to be rising into the importance it deserved, but failing the concurrence of the fortunate circumstances which are necessary to give permanence to invention, was once more forgotten and was left for re-discovery at a happier epoch.

(384.) Early anticipation of steam-carriages. With regard to Steam-Carriages, passing over still earlier speculations, we find that Dr John Robison, at the age of twenty-one, published a design for a steam-carriage in the *Universal Magazine* for November 1757, and that he also directed Mr Watt's attention to the steam-engine in the same year, with a view to this very application. The cylinder of the proposed machine was an inverted one, and Watt actually made a rude model on Robison's suggestion.[3] From this time the steam-carriage seems never to have been long lost sight of by mechanical speculators. It was included in a patent by one Moore, a linen draper, in 1769.[4] In the same year it is stated that Cugnot, a native of Lorraine, actually constructed a steam-carriage, which, like the nearly contemporary but unsuccessful efforts of his countrymen to effect steam navigation, fell speedily into oblivion. About 1773 Edgeworth of Edgeworthstown urged the construction of steam-carriages, and at a later period expressed, in terms of unequivocal anticipation, the triumph arising from their connection with railways. "I have always thought," he wrote in 1813, "that steam would become the universal lord, and that we should in time scorn post-horses. An iron railroad would be a cheaper thing than a road on the common construction." At Soho the movement of carriages as well as of boats by steam never was or could be forgotten. In Watt's patent of 1784 the steam-carriage forms the seventh article, and in the same year[5] Mr William Murdoch, a member of Boulton and Watt's establishment, made a model, acting by high-pressure steam, which drove a small waggon round the room. Hence it required no prophetic power in Darwin, the intimate friend of Watt, to Watt and Murdoch, 1784.

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[1] For historical details connected with Mr Babbage's engine, see Weld's *History of the Royal Society*, vol. ii. An account of the principles and action of the Difference Engine may be found in the *Edinburgh Review* for July 1834; and those of the Analytical Engine in *Taylor's Scientific Memoirs*, vol. iii.

[2] *Principles of Mechanism.* Camb., 1841.

[3] *Mechanical Inventions of James Watt*, ii. 294.

[4] *Mechanical Inventions of James Watt*, i. 52.

[5] *Translation of Arago's Eloge of Watt*, p. 120, *note.*

write those often quoted lines in the *Botanic Garden* (canto i. line 290):—

> "Soon shall thine arm, unconquered Steam, afar
> Drag the slow barge, or drive the rapid car."

(385.) Trevithick and Vivian; their patent in 1802.

A somewhat longer pause now occurs. But in 1802 we find Richard Trevithick, a Cornish "captain" of a mine, taking out a patent along with Vivian for the high-pressure steam-engine, and applying it specifically and practically to the movement of carriages or waggons along a railway at Merthyr Tydvil in South Wales. Mr Muirhead informs us that Trevithick saw Murdoch's model at Redruth in Cornwall. But admitting this, it is plain that the idea was much older still, and also that many years elapsed without its ever being brought practically to bear until the year 1804, when Trevithick's locomotive was actually used.

(386.) Account of Trevithick.

Richard Trevithick appears to have been one of the most ingenious men of his time; but (from the scanty notices which I have been able to collect[1]) to have been also of an inconstant speculative disposition, which prevented him from bringing any of his numerous inventions to perfection. Yet he had the good fortune, which so many inventors have missed, of meeting with partners able and willing to assist him in carrying out his designs. Amongst these was Andrew Vivian, with whom in 1802 he took out the patent already mentioned for the construction of high-pressure engines, and their application to the movement of carriages along rails or common roads. As the first practical employer of high-pressure steam of 60 to 80 lb. pressure on the square inch, Trevithick deserves especial notice. He borrowed the notion of it, as well as the ingenious invention of the four-way cock, from an old scheme of Leupold's, but he overcame for the time the prejudice which had always existed even in the mind of Watt against its adoption. His earliest engine is stated to have been connected with a common stage coach which ran on the streets of London; but his more successful and important effort was made in dragging waggons along the Merthyr Tydvil railway in South Wales, which was successfully tried on the 21st February 1804, when the engine drew carriages containing ten tons of bar iron for a distance of nine miles at the rate of five miles an hour. This was unquestionably the first successful example of this modern species of locomotion.

Applies high-pressure steam to locomotives on railways in 1804.

(387.) Account of his engine.

If we look more closely at the means by which it was accomplished, we find still more reason to commend the sagacity of the inventor. and to wonder at the interval of nearly thirty years which elapsed before the general adoption of his plan. "A square iron case containing the boiler and cylinder was placed behind the large or hinder wheels of the carriage, and was attached to a frame supported from the axles of those wheels. The cylinder was in a horizontal position, and the piston-rod was projected backwards and forwards in the line of the road towards the front of the carriage. Across the square frame, supported by the wheels of the carriage, an axle was extended reaching a little beyond the frame on each side; this axle was cranked in the middle, in a line with the centre of the cylinder, and a connecting-rod passing from the end of the piston turned this axle round, and produced a continued rotatory motion of it when the piston was moved backwards and forwards in the cylinder; upon both ends of this axle cog-wheels were fixed, which worked into similar cog-wheels upon the axles of the wheels of the carriages, so that when a rotatory motion was produced in the cranked axle by the piston-rod it was communicated to the axle of the larger or hinder wheels of the carriages, and these wheels being fixed upon and turning round with the axle, gave a progessive motion to the carriage. Upon one end of the axle was fixed a fly-wheel to secure a rotatory motion in the axle at the termination of each stroke."[2]

(388.)

We here find the cranked axle and the horizontal cylinder of modern locomotives, both of which were departed from by Trevithick himself, probably in consequence of difficulties of execution. When we add to this plain description, that the fly-wheel was furnished with a break, that the boiler had a safety-valve or a fusible plug beyond the reach of the engineer, and that the patent includes the production of "a more equable rotatory motion, ... by causing the piston-rods of *two* cylinders to work on the said axis by means of cranks at a quarter of a turn asunder," it is scarcely too much to say that nothing material was added to the design of the Locomotive until the invention of the tubular boiler in 1829.

(389.) Trevithick's engine explodes.

The Merthyr locomotive blew up, and the prejudice against high-pressure steam revived. The inventor, in the meantime, diverted his attention to other schemes, and continued his profession as a Cornish mining engineer.

(390.) His subsequent career and disappointment.

A singular circumstance opened for Trevithick a new sphere. A Spanish-American gentleman named Uvillé, who was engaged in working the silver mines of Peru, came to England in 1811, with a view to discover an engine fit for draining those mines whose high elevation rendered condensing steam-engines working under atmospheric pressure comparatively inert. In London he met accidentally with a model of Trevithick's engine, and having carried it to the heights of Pasco in Peru, and being satisfied with its work, he did not rest until he had returned to England and transported *nine* high-pressure engines in 1814 to the scene of operations. In 1816 Trevithick himself followed, with coining engines and purifying furnaces of his own contrivance. Had he been a prudent man his fortune was now made; but it is stated that after a year or two he returned to this country impoverished and disappointed. I am unacquainted with his further history.

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[1] It is stated that the Society of Civil Engineers have in vain proposed a medal for a biography of Trevithick.

[2] *Wood on Railways.* This description corresponds with Trevithick's specification and drawings.—*Repertory of Arts*, &c., Second Series, vol. iv.

(391.) In the meantime the locomotive engine, which Trevithick had long abandoned to its fate, was becoming known in the hands of a man perhaps of less genius but of greater sagacity and perseverance.

(392.) George Stephenson; His early difficulties, and character.

George Stephenson, civil engineer, was born in 1780 near Newcastle, of respectable persons in the humblest rank of life. His father was either a common pitman or otherwise employed about the collieries of the district, and young Stephenson, without any advantages of education, began to labour for his bread at an early age. His work appears to have been always connected with the machinery of the pits above ground, and not with their excavation. Thus he rose gradually to be an engine-man at the wages of twelve shillings a week. This was at Killingworth near Newcastle, where he showed considerable mechanical ingenuity, and gradually gained the confidence of his employers. Having married in 1802, he had a son born the following year, the present Mr Robert Stephenson, M.P., whom he brought up with the tenderest care, and whom he ever and justly regarded with a father's pride. In order to bestow upon him the advantage of that education of which he had himself felt the want, it is stated that he made money at extra hours by mending his neighbours' clocks and watches, and finally, in more prosperous days, sent his son to complete his education at the University of Edinburgh. George Stephenson never acquired much book-learning himself, but by natural sagacity and observation he attained to a sound knowledge of mechanical principles. We do not claim for him, however, the character of great inventiveness. His skill rather lay in perceiving how far methods and contrivances already known might be pushed to an advantageous result. He possessed that shrewd decision which ingenious persons often want, enabling him to detect what is truly valuable in the numerous mechanical schemes which at any time are afloat, and to devise the means of realizing them. He also possessed that confidence in his own judgment which is necessary to carry out principles to their legitimate extent, but from which feebler or less practical minds usually shrink.

(393.) He contrives a safety lamp;

Not to interrupt the principal topic of this section, I will here only mention that in 1815 he set about inventing a safety lamp for mines at a time when the recent heavy loss of life in his own neighbourhood had excited general attention; insomuch that Sir H. Davy had been specially invited, by a meeting of persons interested, to propose a remedy. I shall in another place speak of the result; but in the meantime I may state, that George Stephenson made some experiments of his own, which, leading him in the same track which Davy followed, that of admitting the foul air to the lamp through long narrow tubes, might in the end have led him to a construction analogous to that of the safety lamp. As matters stood, it is not surprising that his efforts, though highly meritorious, led him slowly and uncertainly towards the goal which Davy, having once sighted, arrived at with that rapid instinct in which he has never been surpassed. Stephenson was left behind, but was rewarded by a handsome gift offered by his local admirers, who, in doing so, naturally rather considered the difficulties overcome by their humble neighbour than the strictly comparative merit of the two inventions.

(394.) But it is of the locomotive and of the railway that we have here to speak.

(395.) studies the locomotive engine; dismisses the fear of insufficient adhesion to the rails.

The former, we have seen, had been brought to considerable perfection by Trevithick. An engine on his plan had been constructed and used by Mr Blackett of Wylam in Northumberland, near the place where Stephenson resided, and was the basis of his improvements. Blackett's engine had two cylinders, an addition often ascribed to Stephenson, but which, as we have said, was included in Trevithick's patent. What he saw of the performance of this machine appears to have convinced Stephenson, once for all, of the groundlessness of an opinion which then and for long after haunted the minds of railway engineers. This opinion was, that the adhesion between the wheels of a locomotive engine and the smooth iron surfaces of the rails *must* be insufficient to allow the impulsion of the train, at least with any degree of velocity, or up the smallest inclination. Trevithick had a scheme for increasing the adhesion, and this ideal improvement was the subject of repeated patents, some of a singular nature, between 1802 and 1824, one of which, Blenkinsop's, provided a cog-wheel in the engine working into a rack on the rail, which was actually in use down at least to 1830. It is rather a singular thing that men spurning theories, as was the fashion of the engineers of that day, and especially those of Smeaton's school, should have thought as little of an appeal to experiment on so simple a matter as did the followers of Aristotle in the seventeenth century, when Galileo offered to convince them that light and heavy bodies fall equally fast. Forgetting that *direct* friction is always large, and that it varies in proportion to the pressure, these practical men could not get over their first impression, that iron must slide on iron long before a heavy train could be set in motion. It was characteristic of Stephenson's decision of character, that he dismissed all doubts on the subject so soon as his observations seemed distinct, and that he did not hesitate to carry out his belief to its consequences, and to maintain his confidence in the locomotive engine against all antagonists.

(396.) G. Stephenson's improvements.

I shall not stop to particularize Stephenson's first improvements on the locomotive, which were rather in detail than in principle. He saw clearly all along that if it was to work at high speeds he must in every possible way diminish the vibrations and strains to which it was subject, and which would otherwise rapidly wear out the machinery. For this purpose he proposed to connect the engine with its carriage by means of steam acting on six pistons in lieu of springs. But perhaps his most material improvement consisted in the very simple one of throwing the waste high-pressure steam as a blast into the chimney, which was found to increase enormously the force of the fire, and the evaporating power of the boiler. Engines having this improvement, and with two vertical cylinders, as constructed in 1818, are, or were lately (1854), still at work on the Killingworth railway dragging coals at the rate of five or six miles an hour.

The steam-blast.

(397.) Rejects the steam-carriage on roads. One of Stephenson's clear practical opinions was this,—that the locomotive and the railway are part of one mechanism, and must be adapted to one another. He was not a friend to steam-carriages on common roads, and the event proved his sagacity.

(398.) Origin of railways. If the idea of a locomotive belongs to no one man, still less does that of a railway, which being one of the most elementary of mechanical contrivances, may be traced, under some modifications, almost indefinitely backwards, as a means of conveying heavy loads with facility. Hence it was at first confined chiefly to quarries and collieries, especially in underground passages or drifts. The gauge of these subterranean railways, or *tram* ways, was only about 18 inches. The material of the rails was first wood, then cast iron, finally wrought iron, as being less liable to wear and to accident. The wrought iron rail, though not absolutely new, was first generally introduced in 1820. About the same time, or rather sooner, the rails began to be made plain, that is, without any vertical guide or flange to prevent the wheels of the carriages from leaving the rail, and the flange was transferred to the wheels of the locomotive. Even this was not new, for it had been used by Jessop in 1789. The weight of the rails has been constantly on the increase. The original cast-iron rails weighed only 15 lb. a yard; the malleable-iron rail in 1821 weighed about 28 lb., then 35, afterwards 64, and now rails of 80 lb. a yard are generally used.

(399.) Stephenson adapts them to the locomotive. One of Stephenson's first cares was to make his railways solid and level, and to prevent jerks at the junction of the rails. The gauge he adopted, or the interval between the rails (now generally used, except on the Great Western Railway and its branches), was 4 ft. 8½ inches, and was derived from the accidental width of the parent railways in Northumberland. Like Watt and all other innovators, his great difficulty was to get the machinery of his locomotives properly made, and the great railway movement of 1825 was anticipated by the establishment in 1820 of an engine factory at Newcastle, which, till after the opening of the Liverpool and Manchester Railway in 1831, remained the *only* one, and for long afterwards the best of its class. The cranked axle contrived by Trevithick, and abandoned because it could not be properly welded, was now restored; the heavy locomotive was placed on strong but easy steel springs, wrought iron was skilfully introduced into the wheels of the carriages, and the whole machinery was made to work with precision, and to combine a degree of resistance never before anticipated with comparative lightness. The factory was established in 1821, and the first passenger locomotive was started on the Darlington and Stockton Railway in 1825.

(400.) I ought, perhaps, to apologize for these details, but they illustrate so well the exceedingly gradual progress of mechanical invention, that I have thought them worthy of mention here.[1] The subsequent history of the locomotive and the railway is more generally known. From the date of 1825, both grew and flourished; the railway first and most steadily; the locomotive was introduced more cautiously, and met with much opposition; its triumph was almost entirely due to the steadiness of George Stephenson.

(401.) Railway speculations of 1825. The year 1825, so fertile in speculation, produced a series of projects for railways to an extent not commonly known, since few of them came into existence or were even commenced for many years later. The projected capital of these companies amounted to not less than L.30,000,000 or L.40,000,000. But the only considerable undertaking which was at that time seriously supported was the railway from Liverpool to Manchester, and on that battle-field were fought the great questions of the superiority of railways to common roads,—of high to low velocities of transport,—and of locomotives to fixed engines.

(402.) Superiority of railways to common roads. On these three important points, George Stephenson was in advance both of the science and of the practice of his age; and, accordingly, backed chiefly by commercial men, who had entire confidence in his sagacity, he had to maintain the conflict almost single-handed against general and professional prejudice. With respect to the Railway, he had long decided in his own mind against the use of steam-carriages on common roads. This conclusion was scientifically based on his own experiments on the friction of waggons on railways made in conjunction with Mr Nicholas Wood, civil engineer at Newcastle, as far back as the years 1815 and 1816. A simple dynamometer of Stephenson's invention was used, and by means of it the two fundamental propositions were established, that the friction is directly as the pressure, and that it is quite independent of velocity (at least when the speed was moderate). It may be said that these propositions were already known; but, besides that probably Stephenson and Wood were equally unacquainted with the writings of Coulomb, they could not have

Stephenson's experiments on the friction of trains.

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[1] I have found many curious details of the early history of railways in a series of articles on the life of George Stephenson in the *Civil Engineer* Journal for 1848 and 1849. I am indebted to Mr Robert Stephenson, M.P., for many interesting particulars respecting his father's inventions.

dispensed with verifying his results under circumstances so peculiar as those of a railway and a train of carriages. The necessity of doing so was manifested by the opposition, and even ridicule, with which the idea of friction being in this case independent of velocity was received, showing, as has been correctly observed, "how small was the amount of science at that time blended with engineering practice." The friction of even the indifferent railways of those days amounted to only 10 lb. per ton of load; consequently an incline of only 1 foot in 100 would increase by one-half the resistance to the motion of a carriage on a railway. Hence Stephenson determined to construct railways having only the smallest inclinations, and to use fixed engines for higher slopes. With respect to common roads, he showed by powdering even a *level* railway with sand, that the most powerful locomotives then in use speedily came to rest; this, with the previous objection, overruled in his mind the possibility of advantage in that case.

(403.) Practicability of high velocities on railways.

With low gradients and small resistances, together with the proved invariability of friction with speed, there necessarily came into Stephenson's mind the practicability of using high velocities. At a very early period (1816) he spoke in one of his patents of conveying goods "at nearly double the rate at which they were then usually carried along railways," in other words, at 10 or 12 miles an hour, and this he states "with no hesitation, speaking from experiments already made," referring, no doubt, to those on friction made along with Wood about this time. Yet after nine years of farther experience, his old coadjutor Wood deserted him on this grand point, and in the first edition of his book on *Railways* (1825, p. 290) he disclaims the "ridiculous expectation" that locomotives will be seen to travel at "12, 16, 18, or 20 miles an hour," and scorns "the promulgation of such nonsense." Even in 1829 he reported to Messrs Walker and Rastrick, who were referees on the Liverpool and Manchester Railway, "that no locomotive engine should travel more than 8 miles an hour." If at this comparatively late period perhaps the most practised railway engineer in England held these opinions, and *that* with the full knowledge of his friend Stephenson's matured convictions (which it is difficult to believe were not pointed at in this paragraph), we may imagine the opposition which the plans of the latter were likely to meet with from interested or even indifferent persons.

(404.) The Manchester and Liverpool Railway.

At last a company was formed, and funds provided to construct the Liverpool and Manchester Railway. It is unnecessary to state how successfully Stephenson conquered the engineering difficulties of the line, and refuted the predicted impossibility of crossing the Chat Moss. In every respect this railway became a model for those which succeeded, and in essentials very little has been added by 25 years' experience on lines of the same gauge. But now came the struggle as to how this beautiful road was to be worked;—with horses,—by means of fixed engines,—or by locomotives. It was not without a struggle that Stephenson gained his point. Even in 1829 the prejudices of the engineering profession were still strong against the locomotive. And it is curious to read in the contemporary documents with what distrust they were regarded. The clumsy expedient of a series of stationary engines $1\frac{1}{2}$ miles apart, dragging the trains by ropes, would probably have been adopted to the disgrace of the age, but for the energy of Stephenson and his commercial friends. A competition of locomotives was at last agreed to, which took place on October 6, 1829, on a level piece of railway at Rainhill near Liverpool. Though the makers of engines had their energies hampered by various needless conditions (particularly as regards the weight of the engines, under the mistaken notion, that velocity could only be combined with lightness), several excellent engines appeared; but the "Rocket" made at Stephenson's factory at Newcastle, not only gained the prize, but far exceeded in its performances the limits assigned in the programme. It weighed $4\frac{1}{4}$ tons, and dragged a gross load of 17 tons, at the rate of 15 miles an hour, but moved itself with a velocity of 35 miles an hour. The "Novelty" of Messrs Braithwaite and Ericson was also very successful. The prize was awarded to Stephenson, and this success was mainly due to the admirable invention of the multi-tubular boiler, imagined by Mr Booth, and carried out by Stephenson. To distribute the *water* of the boiler in tubes, and allow the heat of the furnace to act around them, was an idea as old as the time of Watt, but it did not succeed. To carry the hot air of the furnace through tubes surrounded by water, was the more successful arrangement of Booth and Stephenson, to the right working of which the draught occasioned by the steam-blast in the chimney was essential. The idea, it is said, had occurred both in France and America, but it certainly remained practically inefficient, perhaps on account of the want of draught.

The locomotive competition of 1829 at Rainhill.

The multitubular boiler.

(405.) Stephenson's success,

This invention, by increasing almost without limit the evaporating power of the boiler, which is the key to the efficiency of a locomotive, completed for the time the skilful improvements on locomotives and railways, which, as has been seen, we owe mainly to Stephenson. The comparatively trifling ameliorations which have occurred in either, and the stereotyped character of even the minor arrangements, such as those of stations and of passenger carriages, show how much the sagacity of the engineer had anticipated the accommodation of the public.[1]

(406.) and its consequences.

I here close my account of Mr Stephenson and of the railway system. The locomotive engine will ever remain as an invention entirely distinct from those created by the genius of Watt. It is in reality independent of his great principle of separate condensation. It has a power of adaptation and a perfection of performance more astonishing than any contrivance of our time, except perhaps the electric telegraph. In 1552, Jerome Cardan took twenty-three days to travel from London to Edinburgh; that the same should be done 300 years later in eleven hours, and every day, is a fact as striking as any which the progress of science presents. Whilst to Trevithick and George Stephenson we are mainly indebted for these results, the theory of the steam-engine is still in arrear. To M. de Pambour we are indebted[1] for by far the best account of the elements of force contained in the locomotive, and of the resistances which they have to overcome; but it is not to be doubted that much yet remains to be done in this direction.

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[1] I do not overlook of course the modifications introduced in the broad-gauge system of the Great Western Railway. Mr Brunel indeed tried to show how far he could deviate without positive injury from Stephenson's plans; in some points, perhaps, he did so with advantage, yet, on the whole, the results do not shake Stephenson's position as the commanding engineer of his time.

M. de Pambour on the theory of locomotives.

(407.) Stephenson dies in 1848.

George Stephenson died 12th August 1848, at the age of sixty-eight, and generally respected for his private character as well as for his talents. His son had the honour of completing the second great railway work in Britain, from London to Birmingham, and by the invention of the tubular bridge, described in a previous section, he has added the most important, as well as the most scientific auxiliary to the extension of railways since 1830.

§ 6. *Hydrodynamics,* DUBUAT, VENTURI, Professor STOKES.—*Friction and Resistance of Fluids.* MM. WEBER, Mr SCOTT RUSSELL.—*Propagation of Waves. Influence on Canal Navigation.* MM. FOURNEYRON *and* PONCELET.—*Improved Hydraulic Machines; Turbine. Reference to the subject of Capillary Attraction.*

(408.) Progress of Hydrodynamics.

There are few subjects less adapted for the kind of discussion which I have adopted in this Dissertation than Hydrodynamics, whether in its abstract or practical form. Not only is it difficult to fix upon individuals who, in the more recent progress of the subject, have attached themselves to it in so especial a manner as to have impressed the science with the individual character of their own minds, but the progress made in either branch has been of a remarkably fragmentary kind, usually bearing upon the solution of individual problems, and tending to the improvement of particular machines. It must be owned, too, that however important in practice may be the efficiency of a water-wheel or the discharge of a pipe, the solution of such problems does not present the attractive interest which attaches to many less difficult ones in Natural Philosophy. As regards more general problems of which a direct solution from first principles might appear possible, it has been found that these are as yet so limited as to give a character (which is generally admitted) of great barrenness to the theoretical investigations.

(409.) While, then, I shall endeavour, in conformity with my general plan, to preserve something of the biographical character in the history, suppressing details and many minor and even some important steps, this section will necessarily have somewhat of a fragmentary character, and its deficiencies must be supplied by a reference to the numerous articles of the Encyclopædia which treat more or less fully of these subjects and their history.

(410.) Dubuat—Friction and resistance of fluids.

1. *Friction and Resistance of Fluids.*—The first name I shall mention is that of the Chevalier DUBUAT, who has the signal merit of having attributed due importance to, and of having considered with much sagacity, the effects of the friction of fluids against their own particles, and against the sides of the solid bodies used to confine them. He had the full advantage of an acquaintance with the Abbe Bossut's excellent experiments and judicious writings, but he was, I believe, the first who succeeded in ascribing to the different forces which act on fluids in a state of uniform motion their effective share in determining their velocity. I refer particularly to the discharge of pipes and of rivers. Dubuat showed that when the motion of water in such circumstances becomes uniform, the accelerating force which acts is the measure of the total resistances to the fluid motion, whether arising from the inequalities of the bed or the viscosity of the fluid. These resistances are assumed to be proportional to the square of the velocity. Since they are exactly in proportion to the length of the pipe or channel, and since the moving pressure increases in the same proportion, the velocity is independent of the length of the pipe, whilst the inclination remains the same—a simple result not previously noticed. In the case of a pipe the *head* or superincumbent pressure may be divided into two parts; one, requisite to force the water into the tube with the requisite velocity, which is independent of the distance to be travelled; the other, which balances the resistance due to the length of the pipe, which for a given diameter varies as the length, or if the slope be constant is independent of the length.

Theory of rivers.

(411.) Mean hydraulic depth.

The relation of the area of the stream to the perimeter or rubbing surface of the channel is then taken into account. This ratio is called by some writers the *mean hydraulic depth.* The manner in which Dubuat derives his formula (which I shall not here set down) from direct experiment, guided by a few general notions of theory, is a very good specimen of this kind of induction, without any pretence whatever of proceeding upon the mathematical theory of fluids in motion. The same views were ably expounded and enlarged by Dr Robison in his excellent article on Rivers and Resistance in this Encyclopædia, through which principally the theory of Dubuat became known in this country. Indeed, viewed apart from the technical value of the enquiry, the research as to the natural economy of rivers is a wonderful and striking branch of terrestrial physics, and one which had long afforded a subject of anxious and perplexing enquiries to Italian engineers from the time of Leonardo da Vinci, though comparatively little studied elsewhere. The collected treatises of Italian authors form an important body of hydraulic information.[1] The rivers of the north of Italy, like those of Holland, conveying vast masses of water charged with mud under very feeble slopes to the sea, present a formidable difficulty which compels attention,—vast territories being increasingly subject to inundation, as the beds of the rivers are raised by deposition above the general level of the soil.

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[1] *The Theory of the Steam-Engine* (1839), and *A Practical Treatise on Locomotive Engines* (1840), by the Comte F. M. G. de Pambour.

(412.) Dubuat's formulæ improved.

Dubuat's formulas have been modified, and made to represent experiments better, by subsequent writers, particularly by De Prony, Langsdorf, Eytelwein, and Thomas Young; and the discharge from mere orifices has been discussed by numerous authors who have given empirical co-efficients to represent the phenomena. But little has been added to a philosophical view of the real laws which govern the fluid motion in this case. Nevertheless Savart and Magnus have made some ingenious observations on the constituent parts of effluent streams.

(413.) Viscosity of fluids.—Venturi—Coulomb.

The *viscosity* or imperfect fluidity of water is the property most difficult to be taken into account in these and other hydraulic problems. It is that which causes the velocity of a stream to diminish from the surface to the bottom, and from the centre to the sides; these proportions were also sought by Dubuat. Each layer of water in motion exerts a dragging or "tangential force" upon other layers, which from any cause are comparatively quiescent; and the experiments of Venturi about the end of the last century, showing that a stream in motion draws towards it the particles of still water with which it may be in contact, with a force sufficient to overcome considerable hydrostatic pressure, attracted much attention. About the same time Coulomb, with his usual address, made experiments on the friction of fluids by observing the rapidity with which cylinders oscillating by means of torsion in different fluids had their original motion destroyed.

(414.) Three cases of fluid resistance to moving solids.

Intimately connected with the friction, and consequent mutual action of fluids, is the resistance which they offer to the passage of solid bodies through them, and this favourite problem of mathematicians was treated by Dubuat, in his inductive way, in an able and practical manner. Three cases may be specified on account of their theoretical or practical importance:—1*st*, In the case of a body oscillating like a pendulum, with small velocities, the body being immersed in a resisting medium; 2*dly*, The resistance to vessels floating on and propelled through water; 3*dly*, The resistance of the air to projectiles whose velocity is very great.

(415.) Motion of pendulums.

Under the first head Dubuat made those ingenious experiments long overlooked, but lately brought into notice, which I have mentioned in the section on the Pendulum in the chapter on Astronomy, Art. (246). The cause of the neglect of these striking and original observations has probably been correctly stated, by saying that in them the pendulum was made subservient to hydraulic experiments, and not the theory of fluids to the improved use of the pendulum; and they were therefore overlooked by those whose studies were connected with the pendulum and its applications. The fact observed by Dubuat was, that a large mass of air (or of water in the corresponding case) is carried along with a pendulum in motion, and affects in a sensible manner the time of vibration, quite independent of the diminution of gravity due to the buoyancy of the pendulum. The moved mass of air was proved by hanging a film of worsted from an arm a foot long in advance of the moving sphere, when it was found to be but slightly driven by the inertia of the air through which the pendulum moved. Dubuat significantly calls the mass of moved air "the prow" of the moving body, and it is easy to anticipate the sort of effect which such a graduated condition of the surrounding air from motion to absolute rest would produce.

(416.) Professor Stokes's solution. Defines the *index of friction.*

But the most surprising thing is, that mathematicians should have attempted to compute the effect, or should have been in any degree successful in doing so; yet after the preliminary efforts of Poisson and Green, Professor Stokes has introduced for the first time a correct definition of the "index of friction" of a fluid, and after great labour has succeeded in finding *exact* expressions for the motions of a solid sphere and cylinder. This investigation may be found in a very elaborate paper in the *Cambridge Transactions*,[2] in which he solves the equations found by him in a previous paper,[3] in the cases of pendulums having the forms just mentioned. Another interesting result of his investigation is the immense effect of fluid friction in retarding the fall of minute rain drops, which he states to be such as to explain satisfactorily the suspension of clouds. In the second part of the paper I have first cited Mr Stokes proceeds to compare his theory with the observations on the pendulum mentioned in Art. (246), and the agreement appears satisfactory. With reference to Coulomb's experiments on oscillating disks there remains some doubt whether the theory applies satisfactorily to viscid fluids such as oil.

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[1] *Raccolta di Autori che trattano del moto dell' acque*, 10 vols., 1822–26; and *Nuova Raccolta*, 7 vols., 1823–45. See also the admirable methodized catalogue of writers on Hydraulics in the second volume of Young's *Lectures on Natural Philosophy.*

[2] Vol. ix. part ii.—*On the effect of the internal friction of Fluids on the motion of Pendulums.*

[3] *On the friction of Fluids in motion.* Camb. Trans., vol. viii., part iii.

(417.) Naval architecture. On the very difficult and still empirical subject of naval architecture as regards forms of least resistance, I shall not here speak; but one very interesting case of the resistance of fluids in canals will be noticed in the course of this section—Arts. (422), &c.

(418.) Resisted motion of projectiles. The theory of military projectiles has perhaps received no improvement so considerable during the last 100 years as by the previous experiments of Robins, and the invention of the Ballistic Pendulum referred to in the preceding Dissertation; though the experiments of Borda in France, and of Hutton in this country, have of course increased the technical precision of artillery. Poisson has considered, in a mathematical way, some of the simpler cases of projectiles moving with a moderate velocity.

(419.) Experiments on waves in water. II. *Experiments on Waves.*—MM. Weber—Mr Russell.—Whilst the theory of the dilated and compressed waves which constitute sonorous vibrations in elastic fluids was being successfully investigated by Lagrange and Laplace, the case of waves in water, due to a disturbance of hydrostatic pressure only, was attacked by the same mathematicians with far less success. It is generally allowed that the more recent and abstruse researches of Poisson and M. Cauchy, though very valuable as improvements in pure mathematics, have been also singularly barren of valuable results admitting of the very desirable confirmation of direct experiment. The greatest of all hydrodynamical problems, that of the Tides, is, as has been seen in the second section of the chapter on Physical Astronomy, Art. (69) &c., so excessively complex as to be the last, instead of the first, which analysis might have been expected to resolve. When, on the other hand, we see the light which has been thrown even upon it by experiments on a comparatively small scale, we learn to value them in proportion to their rarity.

(420.) Observations of MM. Weber on the form of waves. The brothers **Ernst Heinrich Weber** and **Wilhelm Weber**, known for many ingenious experiments in physics, and particularly in magnetism, are the authors of a useful book on waves.[1] They made experiments on the velocity of waves in glass troughs, by means of which they determined in several cases the velocity of the wave with different depths of fluid; they also ascertained mechanically the form of the wave, which they found to be that of the curve of sines. But the most important of the Webers' experiments is probably the determination of the motion of individual particles of the water, which they ascertained by watching from the exterior of the glass trough the curve described by minute floating particles as the wave passed over them. The usual form of the trajectory is an ellipse having the greater axis horizontal, the whole ellipse being described when the wave includes a ridge followed by a depression of the surface; but if there be only an elevated wave propagated, then a semi-ellipse is described in the direction in which the wave moves, and the particle returns to rest in a new position; if the wave be a hollow one the converse takes place. The limits of oscillation diminish with the depth of the fluid, particularly the vertical limits; consequently at some depth the motion of the particles is nearly in a short straight line. The rapidity of the degradation of the individual motions depends on the relation between the length of a wave compared to the depth of the fluid: where the wave is very short compared to the depth of fluid, the ellipses near the surface become circles, and the motion rapidly disappears beneath; when the length of the wave is great compared to the depth of fluid, the motion of the particles is nearly the same from top to bottom. The conclusions of theory are on the whole confirmed by these experiments. Trajectory of a particle.

(421.) Mr J. S. Russell's experiments on waves. The experiments of Mr **John Scott Russell**, so far as we shall notice them, refer to two closely connected subjects:—the transmission of waves, and the resistance of water to vessels propelled through it as affected by waves. They are principally to be found in the *Edinburgh Transactions*, vol. xiv., and the British Association Report for 1837. The velocity of waves in troughs of different depths and sections was ascertained by allowing the wave to be reflected at either end of the trough, which does not in any way affect the time of its propagation, and gives great facility for accurate observation, as the distance travelled over may thus become large, at the same time that all casual and interfering waves are gradually eliminated. The instant of the passage of the wave was ascertained by reflecting the light of a candle vertically upwards from its horizontal summit. The length of the trough was 20 feet, but since the wave was made to traverse it as often as 60 times, a distance of 1200 feet was really observed. The waves were single or "solitary" waves, either "positive" produced by a gush of water from behind a sluice, or "negative" by withdrawing water suddenly. Mathematicians seem not agreed as to whether or not the "solitary" waves of Mr Russell are to be treated as a species apart.[2] Unquestionably it has long been known that a partial wave either positive or negative may be propagated without any farther disturbance of the fluid. Theory also shows that the velocity of a wave *long in proportion to the depth of the water* is nearly as the square root of the depth; but it does not clearly ap-

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[1] *Wellenlehre auf experimente gegründet, oder über die Wellen tropfbarer Flüssigkeiten mit anwendung auf die Schall und Lichtwellen.* Leipzig, 1825.

[2] Compare Mr Airy in the article "Tides and Waves," *Encycl. Metropolitana;* Prof. Stokes in *British Assoc. Report* for 1846, and Mr Earnshaw in *Cambridge Trans.*, vol. viii.

Compared with theory by Mr Kelland and Mr Airy.

pear whether the disturbed or undisturbed depth is to be taken. The analysis of Mr Airy seems to show that a depth somewhat greater than that due to the utmost effect of disturbance is to be preferred. Mr Russell also made experiments on the propagation of waves in channels of different forms of section. Professor Kelland has given a very simple expression for the velocity of the wave in this case,[1] which on the whole agrees with experiment.

(422.) Peculiar effect of wave transmission on canal navigation.

Sometime about the year 1830, attention was drawn to a singular fact connected with the resistance of water in the case of canal navigation. It was first noticed I believe in Scotland, probably on the Forth and Clyde Canal. It amounted to this, that whereas at moderate or rather slow velocities, the resistance to a boat increases with the square of the velocity,—after a certain point, not differing very much from 7 miles an hour, the resistances not only cease to increase according to the same rapid law, but *actually diminish* to some extent when the speed is greater. Different experiments were made by the canal proprietors with a view to meet in some degree the active competition by railways, then commencing. Mr Russell was employed by the directors of the Forth and Clyde Canal, and to his experiments we now refer. It appears from his tables that the resistances increased on the whole *faster* than the squares of the velocities up to 7½ miles an hour, when they suddenly *diminished* between 7½ and 8½ miles an hour by *one-fifth* part in one experiment, and by no less than *one-third* in another.[2] It was not until about 12 miles an hour, that the resistance reached the same amount as at 7½ miles.

(423.) Practical results.

The occurrence of this singular transition was attended with a phenomenon easily noticeable. In every ordinary case a boat in a canal drives a wave before it, which is in fact a heap of water resisting the boat by increasing the pressure against its bows, which wave may be called a *forced wave*, having this peculiarity that it travels with the speed of the boat and never quits it; whilst a *free wave*, by whatever cause excited, is propagated at a rate depending only on the dimensions of the canal, particularly its depth. Now the diminished resistance takes place when the boat is by the force of traction partly drawn out of the water, and lifted up upon the wave to which its own motion gives rise. It is said to *ride* upon the wave, and the head of water pressing against its bows is visibly diminished. The most advantageous rate of transport was found to be about one-third greater than that required merely to mount the wave, which last depends principally on the depth of the canal. Thus on three different canals, 3½, 5¼, and 9 feet deep, the most advantageous velocities were 8, 11, and 15½ miles an hour. The actual velocities of the *free* wave were ascertained by Mr Russell in an ingenious and satisfactory manner. When the boat is dragged to most advantage, the draught of water is less at the stem and stern than in the centre. All these circumstances have been very ingeniously and satisfactorily explained by Mr Airy in his paper on Tides and Waves, articles (404–411).

(424.) Forms of ships.

Many persons (amongst whom are Colonel Henry Beaufoy, Mr Scott Russell, and the American shipbuilders) have bestowed much attention on the forms of vessels for ensuring speed, especially by the avoidance of waves of various kinds generated by steam-vessels in motion. Every one who can compare the performance of such vessels during the last twenty years, and the still surface which waters navigated by steam vessels now present, as if they were merely cut open and closed again before and after the passage of the ship, instead of being tossed into dangerous billows consuming uselessly the propelling force, will readily admit that, however imperfect the theory, practical art has made real progress in this direction.

(425.) Improved hydraulic machine—the Turbine.

III. *Improved Hydraulic Machines—Turbine.*—Before concluding this section, I will refer to the most considerable improvement made of late years in the application of hydraulic pressure to motive purposes, and I shall couple it with the names of two French engineers, MM. FOURNEYRON and PONCELET, the former the inventor of the *Turbine* (the machine referred to), at least in its improved practical form; the latter an important contributor to the useful application of hydraulics, an accomplished mathematician, and the author of several standard works connected with industrial mechanics.

(426.) Defects of common water-wheels—Barker's mill.

The defects of common vertical water-wheels, whether overshot or undershot, are so great and so notorious, that only their simplicity, and the fact that in very many cases water-power costs next to nothing, and may be squandered with impunity, could justify their use. The advantage of using the simple *pressure* of a fluid as a moving power had been foreseen in that application of re-action called *Barker's Mill;* which, though well known in models, was seldom if ever applied in practice. Mathematicians were, however, aware that it offered important advantages. Of late years a patent has been taken out in Scotland for a modification of it, which is found, I believe, to work well. But the *Turbine* or horizontal water-wheel imagined by Burdin and Fourneyron, and brought to a high state of perfection by the latter about the year 1833, appears to exhaust all that is valuable in this mode of applying water.

(427.) Fourneyron's turbine.

Referring to other parts of the Encyclopædia for the details, I may here explain generally that the Turbine consists of two parts, one a fixed cylinder or drum of small height compared to its diameter; the other a portion of a cylinder exterior to the former, and moveable round it, so that the inner surface of the moveable cylinder is all but in contact with the circumference of the fixed cylinder. Further, water under a greater or less hydrostatic pressure, and moving with the consequent velocity, is introduced at the centre of the fixed cylinder, and conveyed to its circumference by channels of a peculiar form constructed by means of vertical partitions or guides of continuous curvature, from which the water is discharged against float boards within the external cylinder, which are also curved, but the curvature is turned the other way so that the partitions in the first cylinder are where they terminate *nearly* perpendicular to the internal surface of the moveable or second cylinder where they commence. These latter partitions or float-boards terminate exteriorly in a direction nearly tangential to the outer cylindric surface where the water emerges.

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[1] Velocity $= \sqrt{\frac{g\,A}{b}}$; where A is the area of section of the canal, b the breadth of the water at the surface, and g the accelerating effect of gravity. *Edinburgh Trans.* vol. xiv.

[2] *Edin. Trans.*, vol. xiv., p. 48.

(428.) Principle of greatest advantage in water-wheels.

The hydraulic principle of greatest possible advantage to which these *Turbines* are made as nearly as possible to approximate is this, *that the water shall enter the moveable apparatus without shock, and shall quit it without velocity*, being simply *left behind* by the wheel as it escapes from it. Since both these conditions cannot absolutely be fulfilled, the first part of the condition is left imperfect. Some secrecy is, I believe, still maintained as to the forms and dimensions of these machines; but their actual efficiency has been most thoroughly tested by means of De Prony's Friction Dynamometer[1] by Colonel Morin, a most competent authority. His experiments leave no doubt of the admirable qualities of these machines. In particular, the *useful effect* compared to the theoretical effect represented by the fall of water expended rises higher than probably in any other hydraulic machine, being under favourable circumstances about *eighty per cent.* Now water-wheels moved principally by the shock of the fall seldom, in the most advantageous conditions, realize thirty-five per cent., often not seven per cent. This superiority of action of the Turbine is due entirely to the approximation which it gives to the theoretic condition above mentioned of perfect efficiency.

(429.) Power of adaptation of the turbine.

But what is not less striking in the performance of this machine, is the variety of circumstances under which it acts advantageously; however great may be the variation in the size and velocity of the wheel, the height of fall, and the power disposable. Turbines have been made of as small diameter as 2 feet with the enormous fall of 350 feet, making 2300 revolutions per minute. They work with nearly equal advantage (relatively to the power expended) whether the supply of water be small or great. They may be completely *drowned* or buried under water to a considerable depth without any sensible variation in their efficiency, thus preventing any inconvenience from floods.

It is remarkable that, with these manifest advantages, the Turbine has been so sparingly introduced at least in this country. No doubt the first establishment of it is attended with considerable expense. (430.)

(431.) M. Poncelet—efflux of fluids—breast-wheels.

M. Poncelet, an active and intelligent officer of *Génie*, and member of the Institut, is favourably known by his hydraulic observations and inventions, as well as by his skilful investigation of the effects of machines, and his excellent works and memoirs on several subjects. He has investigated with much patience and geometrical nicety the form and discharges of spouting fluids, and was one of the first to improve materially the ordinary water-wheels, by introducing a kind of *breast-wheel* (which thirty-five years ago was scarcely known in France) in which the water is conveyed without shock into compartments on the descending side, from which again it was allowed to escape with all its acquired velocity spent, or nearly so. The efficiency of these wheels is equal to about two-thirds of the power expended. Before the Turbine had been finally improved by M. Fourneyron, M. Poucelet had invented an engine on the same principle, in which the water enters at the circumference of the horizontal wheel, and is delivered at the centre.

(432.) Capillary attraction—Young and Laplace.

I am aware how imperfect this section remains as a history of Hydrodynamics. But I must again refer to special articles on the subject, the plan of the Dissertation not admitting of farther detail. As nothing material has been added to the doctrine of Capillary Attraction since the publications alluded to in Sir John Leslie's Dissertation (although M. Poisson has written a treatise on the subject), I will for the sake of compression not enlarge upon it. I do so with the less regret, because I cannot regard the excessive mathematical illustration which it has received as altogether justified by the certainty and due appreciation of the physical principles involved, such as can alone give to applied mathematics their distinctive value. The theory of Laplace, so far as it was based on novel grounds, was anticipated by Dr Young, and gave rise to several controversial articles by that most eminent philosopher, of which an account will be found in *Dr Peacock's Life of Young*, pages 199-210, as well as a most excellent review of the subject of Capillary Attraction, which, indeed, by its candour and completeness, supersedes anything which I should have felt disposed to say on the subject.

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[1] Gaspard de Prony, born in 1755, was an eminent engineer, especially in the department of hydraulics, and the author of a voluminous work entitled *Nouvelle Architecture Hydraulique;* but his originality was not great enough to authorize his being placed among the leaders of his age. His simple invention of the *Frein Dynamometrique*, or friction dynamometer, is the one by which perhaps he will be longest remembered. It consists of an iron collar with tightening screw, which may be clasped on a horizontal wooden arbor connected with uniformly revolving machinery. A lever, to which a weight may be applied, is attached so as to form part of the collar. The clasping screw being moderately tightened, the collar and lever are of course carried round by the machinery until a weight is applied sufficient to check the velocity, and to generate an amount of friction which is in fact the useful effect of the machine for that velocity, and which is determined by the momentum of the weight overcome in one second. De Prony was a most amiable man, and died in 1839, in the 84th year of his age.

§ 7. *Progress of Acoustics.* Chladni—Savart. *Laplace's Correction of the Theory of Sound. Vibrating Plates and Acoustic Figures.* Cagniard de la Tour's "*Sirène.*"

(433.) Mathematical theory of the propagation of sound.

The mathematical theory of the propagation of sound, considered as a branch of analytical mechanics, made far greater progress during the eighteenth century, in harmony with the general character of the science of that period, than the inductive doctrines of acoustics. Newton here, as in other departments, overstepping the limits of knowledge of his day, left a legacy of toil to his immediate successors. Lagrange had the most distinguished good fortune in reducing the theory of aërial tremors under their most general conditions to the laws of mechanics by the calculus of partial differentials; and Laplace supplied the link which was wanting to reconcile the result with the known mechanical properties of air. As the former of these matters belongs more properly to the period of the previous Dissertation, and as the beautiful discovery of Laplace has been more especially touched upon by Sir John Leslie, it will be sufficient here to recall the fact that the spring of air, or the effort by which it tends to re-expand under sudden compression or to contract to its former bulk when suddenly dilated, is *increased* by the heat extricated in the former case, as well as by its absorption in the latter. And as sonorous pulsations are held to consist of a series of compressed and rarified waves whose velocity is affected by the recoil of air, it appears certain that the velocity must be increased by this circumstance, though it is difficult to determine experimentally the exact amount.

Laplace's correction of the theory.

(434.) Chladni the reviver of experimental acoustics.

The revival of experimental acoustics is due to Ernst Chladni a native of Saxony, but of Hungarian extraction, born in 1756. Little had been done in this department since the time of Sauveur, who ascertained the nature of the harmonic vibrations of strings, and that of Daniel Bernouilli, who considered the analogous case of organ pipes. We are indebted to Chladni for two classes of original experiments—his measure of the velocity of sound in a variety of bodies by peculiar and ingenious methods; and his observations on the vibrations of plates by means of the ingenious expedient of strewing them with sand and other powders.

We shall say a few words under each of these heads:—

(435.) Velocity of sound in different media;

I. Chladni observed the velocity of sound in air of different densities, and in different gases, by using a flute of metal which was sounded by means of the elastic fluid required, and the resulting note enabled him to determine by an easy calculation the speed of propagation of the tremor. This method (using an organ pipe) has been more lately resorted to by Dulong for the purpose of deducing the properties of different gases with respect to heat, by ascertaining from experiment the co-efficient in Laplace's correction for the velocity of sound. Chladni was also probably the first to notice the *longitudinal* oscillations of strings and rods which always yield a note immensely sharper than the lateral vibrations. By means of the former he ascertained the velocity of sound in a variety of woods and metals, in some of which it is no less than seventeen times greater than in air. These observations are not only interesting in themselves, but as throwing light on the constitution of solid bodies. To Chaldni we likewise owe a knowledge of the *twisting* vibrations of rods, which exhausts the modes of vibration of such bodies. To connect theoretically the periods of these different kinds of movement, has been a favourite problem with recent mathematicians, but has not even yet been quite successfully performed.

(436.) In water.

The determination of the velocity of sound in water, an experiment by no means difficult, was reserved for MM. Colladon and Sturm, who observed it on the Lake of Geneva, and found it to be 4708 English feet per second, a result closely conforming to the theoretical amount deduced from Oersted's observation on the compressibility of water.

(437.) Chladni on the vibration of plates.

II. But Chladni's experiments on the vibrations of plates are of still greater interest and originality. Though it has been affirmed that Galileo strewed sand or light substances upon the sounding boards of musical instruments,[1] Chladni deserves the entire credit of rendering this an exact method of ascertaining the *nodal lines* or points of rest in bodies vibrating in a stable or permanent manner. He first applied it to plates round, square, or of different figures, supported horizontally and caused to vibrate by applying a violin bow to their edges. Dust or fine sand strewed or sifted uniformly over such a plate, arranges itself in a variety of beautiful figures, being tilted from the greater part of the surface, and heaped up on those parts which are at rest in consequence of the vibratory motion of adjacent parts taking place simultaneously in opposite directions; just as the nodal points of a string vibrating harmonically are without motion on the same account. The number and variety of figures thus producible in the same plate is very great, and corresponds, as Chladni clearly saw, to different simple harmonical vibrations of the elastic plate, being accompanied by their appropriate notes; or by the superposition of several such modes of vibration, and of the corresponding sounds. The tract published by him in 1787 entituled, *Entdeckungen über die Theorie des Klanges*, contains numerous figures of these appearances, which,

Acoustic figures.

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[1] This, however, is very doubtful. See Dove, *Repertorium*, iii. 106.

more recently, Savart found the means of preserving by transferring them to sheets of gummed paper. There are few experiments in physics of a more striking character, or which so plainly reveal minute and complex motions so small and so rapid as to be difficultly appreciated otherwise. Mr Faraday and Mr Wheatstone have pursued the same enquiry experimentally, and the latter has satisfactorily deduced the figures of Chladni's square plates from the mechanical superposition of simple modes of vibration which are symmetrical and isochronous. (*Phil. Trans.* 1833.) By so doing he has succeeded better than the mathematicians, whose results on this subject have been very little practical.

(438.) In bodies possessing unequal elasticity. Chladni was the first to make experiments on the vibrations of bodies whose elasticity varies in different directions. Thus he cut plates out of different kinds of wood, and found the nodal curves unsymmetrical in different directions depending on the course of the fibres. The experiments were naturally afterwards employed to illustrate the theory of ellipsoidal waves on the undulatory hypothesis of Optics.

(439.) Chaldni on meteoric bodies. The experiments of Chladni procured for him the especial notice of Napoleon, by whose wish one of his works was translated into French. He died in 1827, and besides his acoustical discoveries, he will be remembered by the sagacity and boldness with which he maintained the popular opinion of the fall of heavy meteors from the sky, contrary to the prevalent scepticism of philosophers. Chaldni's success in establishing this important fact in natural history is due, like his other physical inductions, to the constancy and simple-mindedness with which he attached himself to a strictly definite enquiry.

(440.) Young—Robison. We must not here enlarge upon the ingenious and important investigations of Dr Thomas Young connected with acoustics. Being chiefly connected with his admirable Theory of Light, they will be noticed in the chapter on Optics. The peculiarly practical and sagacious views of Dr Robison connected with the Theory of Musical Instruments and Acoustics generally, must also be passed over.

(441.) Savart. In Felix Savart we find a man like Chladni who was especially devoted to a single and circumscribed branch of science—acoustics. His published researches are almost all detached notices in the *Annales de Chimie*, with a few memoirs in the publications of the Institute; and whilst they are very interesting, exact, and instructive, I doubt whether it would be possible to place the results in a connected and comprehensive view before the reader. They are therefore rather to be sought in the special articles of the Encyclopædia devoted to the subject. In general they may be stated to refer to the following topics:— Propagation of sound in masses of air, &c. (1.) To the manner of propagation of sound through the air and through liquids, with an attempt to explore the manner in which sounds spread in apartments of different forms; an enquiry as difficult as it is important; (2.) To the generation and audibility of musical notes. On the production of musical notes. Previous authors (for example, Chladni, Biot, and Wollaston) having differed materially as to the range of audibility of repeated equidistant impressions which affect the human ear as musical notes, Savart used a simple method, no doubt original to him, but anticipated I believe by Robison, in which a card is held near or touching a revolving wheel, and the number of impulses (each double) given to the air by every tooth as it passes the card, is readily measured. He thus found that a note occasioned by 24,000 *double* vibrations in a second is perfectly audible; and, at the other limit of the musical scale, from seven to eight equidistant beats constitutes a sound having a distinct *pitch*. According to Savart, *two* consecutive double impulses of whatever duration are sufficient to convey to the ear the sensation of pitch. *Sirène* of M. Cagniard de la Tour. But a more elegant and accurate instrument for the numeration of sonorous pulsations is the *Sirène* of M. Cagniard de la Tour, unquestionably one of the most exact and satisfactory additions lately made to our experimental apparatus. In it a current of air is repeatedly interrupted and renewed, giving rise to a series of impulses similar to those of the toothed wheel; and this apparatus is ingeniously contrived, so as to maintain its own motion, and record its indications. It is by far the most accurate known method of ascertaining the pitch of a given note. It may also be worked with water. Robison had also the merit of the primary idea of the Sirene, by making a stopcock revolve rapidly whilst applied to a tube emitting a blast of air. Savart on the vibration of solids. (3.) Savart extended the researches of Chladni by means of sand to many new cases, and with interesting results; in particular he exhibited the effects of the unequal mechanical elasticity of crystals cut in different directions. He has also examined with great care and ingenuity, the nature of the vibrations which occasion the accumulations of sand on the nodal lines of plates, and he comes to the conclusion that they are determined by simultaneous transverse and longitudinal movements (the latter of which are parallel to the surface of the plate). In proof of this he shows that in long rods or hollow cylinders, the position of the nodes is intermediate and opposed upon the contrary sides of the rod or hollow cylinder. Savart made many experiments on the communication of vibrations from one body to another; showing that the molecular movements generally preserve their parallelism, so that a longitudinal vibration of one body may give rise to transversal movements in another; and he applies this to the theory of musical instruments.

(442.) Biographical notice of Savart. Savart was born at Mezières in the department of Ardennes, on the 30th June 1791; and died somewhat prematurely on the 16th March 1840. He had some peculiarities of temper, amongst which was his unconquerable prejudice to everything English. He did not even acknowledge the intimation of his election as a foreign member of the Royal Society of London. It is to be regretted that Savart never published a connected account of his observations. He had caused to be collected at the *Collège de France*, where he was professor, an unequalled collection of acoustical apparatus, a great deal of which was contrived by himself, and where he delivered extensive courses of lectures on this subject alone.

(443.) Other acoustical experiments. Several English philosophers, in particular Professor Willis, Mr Hopkins, and Mr Wheatstone, have written several important detached memoirs on particular practical points, for which we must refer to special treatises.[1] The first and last of these gentlemen, together with some Germans, have approximated in some degree to the formation (on empirical principles) of a speaking machine.

CHAPTER V.

OPTICS.

§ 1. THOMAS YOUNG.—*The Undulatory Theory of Light.—Its history from the time of Hooke and Huygens.—The Law of Interference.—Its application to Diffraction—to the Rainbow—and to other subjects.—The Theory of Polarization referred to another section.*

(444.) Small progress of optics in the 18th century. THE history of Optics in the eighteenth century is one of the blankest pages of scientific story; at least if we allow Bradley's discovery of aberration to be (as it really is) rather an astronomical than an optical discovery. The most notable advance was unquestionably the invention of the achromatic telescope as narrated in the Fifth Dissertation,[2] founded on the proof of Newton's oversight in the matter of dispersion. The construction of refracting telescopes made rapid advancement in the workshop of Dollond, whilst reflecting telescopes, in the hands first of Short, but far more conspicuously, of Sir William Herschel, were shown to be capable of making unimagined discoveries. The geometrical theory of optical instruments was also greatly improved; but all this led to little increased knowledge concerning Light itself. If we except the valuable though imperfect treatises of Bouguer and Lambert on the subject of photometry, and a paper by Mr (now Lord) Brougham in the last years of the century, recalling attention to the inflexion of light, the history of Physical Optics (as that part of the science touching more immediately the nature and qualities of light is now usually termed) is almost a blank from the publication of the Optics of Newton in 1704 to that of Young's papers almost one hundred years later.

(445.) Thomas Young. It is not therefore from overlooking Young's predecessors that we open our review of the recent progress of optics with his discoveries. We here meet with a man altogether beyond the common standard, one in whom natural endowment and sedulous cultivation rivalled each other in the production of a true philosopher; nor do we hesitate to state our belief that since Newton, THOMAS YOUNG stands unrivalled in the annals of British science.

(446.) His early education and attainments. He was born at Milverton in Somersetshire on the 13th June 1773, and his biographers dwell with complacency on the prodigies of his youth, uncertain as such attainments confessedly are in stamping the greatness of the future character. At the age of fourteen he had learned (principally for amusement) seven languages besides his own, and besides had made a point of mastering every subject, whether in science or miscellaneous knowledge, which he had once determined upon prosecuting. Thus, whilst studying botany he resolved to learn how to make a microscope, but finding in Martin's Optics the notation of fluxions, he became his own preceptor in that branch of analysis. "He acquired a great facility in writing Latin. He composed Greek verses which stood the test of the criticism of the first scholars of the day, and read a good deal of the higher mathematics. His amusements were the studies of botany and zoology, and to entomology, in particular, he at that time paid great attention."[3] Dr Young's education was almost completely private. Having been brought up according to the tenets of the Society of Friends, he had not thought of going to Cambridge

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[1] See also Herschel *on Sound* (*Encyc. Metrop.*); and Whewell's *History of the Inductive Sciences*, vol. ii.

[2] It may be mentioned, however, that the credit usually ascribed to Dollond must be divided, at least, with Mr Hall, a private gentleman of Worcestershire, who not only imagined but constructed achromatic telescopes as early as 1733 (*Gentleman's Magazine*, 1790, and *Phil. Mag.*, vol. ii.) The improvement by Dr Blair of Edinburgh has been alluded to in Sir John Leslie's Dissertation. It consisted in enclosing fluids in the object glass, of such composition as to disperse the several rays of the spectrum in the *same proportion to one another* (though not to the same absolute amount) as the glass with which it was combined; thus rendering the achromatism more perfect.

[3] Memoir of the Life of Thomas Young, M.D. 8vo, 1831. The present section of the Dissertation was written shortly before the publication of the *Life and Miscellaneous Works of Dr Thomas Young*, for which the public is indebted to Dr Peacock, Dean of Ely, the possession of which would have materially facilitated my task. Wherever Dr Peacock's information has

Residence at Edinburgh;

(which would have been his natural destination), and entered the university of Edinburgh as a medical student at the age of twenty-one. He had already declined the overtures of such distinguished patrons as Windham and Burke, resolving to devote himself to the pursuit of science, for which a medical education seemed to him a fit entrance;—his studies being made under the more immediate advice of his uncle, Dr Brocklesby. He attended Black's lectures in Edinburgh; whether he was known to Robison I am not aware, though I should be inclined to infer that he was from the terms in which Robison speaks of Young when criticising his strictures upon Smith's *Harmonics*. Robison disagreed with him on this point, and also about the nature of light, yet he speaks of Young and of his paper on Sound with very marked respect. More than a year before his enrolment at Edinburgh (which took place in autumn 1794), he communicated to the Royal Society of London a paper on vision, of which we shall presently give some further account; and was elected a fellow of the Society when just of age.

(447.) at Göttingen and at Cambridge.

From Edinburgh he proceeded to Göttingen where he graduated; acquiring the German language, and leaving a vivid impression of his astonishing versatility of talent and powers of memory. Early in 1797 he returned to England, and soon after entered himself at Emmanuel College, Cambridge, in order to comply with the requisitions of the London College of Physicians, and thus to obtain a license to practice. For the next few years his time was divided much between Cambridge and London. He was now twenty-three years of age, and his mental habits too much formed to bend to the rules of Cambridge study. When the master of his college introduced him to the fellows, he is reported to have said, "I have brought you a pupil qualified to read lectures to his tutors," and such, no doubt, was the fact. We hear little of his occupations at Cambridge, but we can hardly doubt that his private studies then ranged over the vast fields of erudition which he afterwards proved that he had made so completely his own; and we cannot doubt that he was then preparing the groundwork of his theory of optics, although his discovery of interference was certainly not made at Cambridge, and probably in London after his settlement there in 1800.[1] His first paper on sound and light is dated from Cambridge in July 1799.

(448.) Character of his investigations.

I have entered into these details because they throw light on the peculiarities of Young's character and attainments. He was to a great degree self-educated; and his studies in consequence may be called desultory, though none would dare to call them superficial. Mathematicians may consider his acquaintance with their science as not technically complete, yet one of them admits that "he could make a small amount of mathematics go farther than any one else." Had he been a consummate analyst it is unlikely that we should have had in him the author of the undulatory theory, the difficulties of which in its earlier stages made it unpalatable to Laplace, Poisson, and the most considerable French mathematicians. Having thought out for himself every one of the multifarious subjects with which he grappled, his writings have a striking force and originality, and his reports of the labours of others are almost invariably drawn from a study of their original works. His earliest principle was, that what one man has done another may accomplish; and one of the many respects in which he resembled his great predecessor Newton, was unbounded confidence in the powers of "patient thought." Not that he confined the desire to excel to purely intellectual matters. What he found it worth while to do at all, he thought it worth doing well. He chose to be first-rate in dancing and in equitation;—his penmanship was (in his early days) as scrupulously elegant as his scholarship.

(449.) Young's *Lectures on Natural Philosophy.*

In 1801 Young was appointed Professor of Natural Philosophy at the Royal Institution, where he was the colleague of Davy. Young had not the qualifications of a popular lecturer, and the most important result of his short connection of two years with the Royal Institution was the publication in 1807 of his *Lectures on Natural Philosophy*, in two large quarto volumes. It is a work peculiarly characteristic of the author; and is rather adapted for reference by the scholar, than to be studied as an elementary treatise. Its condensation is such as to render it in many places obscure; though when read by one conversant with the subject, its comprehensiveness and precision are surprising. It is a truly admirable monument of labour and genius combined. Embracing the arts as well as the whole of natural philosophy, it seems to include the mention of everything connected with his vast subject from the simplest tool of the artisan to the highest speculations of Newton and Lagrange; and yet it is evident, by the masterly manner in which he handles it, that the author had made all this mass of knowledge completely his own. The catalogue of references with which it closes indicates an extent of bibliographical research which would have done honour to any one who had made that an exclusive object of study. Even the plates are drawn with a studious care, betokening well his own mechanical talent.

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enabled me to improve the text I have not hesitated to use it. The facility of consultation afforded by the collection of Dr Young's widely scattered writings is a most important aid to all future students of science, and one which cannot fail to raise still higher the great reputation of their author.

[1] See Sect. vii. of the article POLARIZATION in this Encyclopædia, where, in a bracketted interpolation by the translator, Dr Young, he speaks of this fundamental experiment being made "in the room and at the table on which he is now writing." This must have been in Welbeck Street, London.

Many of the figures, though of hackneyed subjects, are represented in a novel manner; there seems not a line drawn at random. Such figures often illustrate better than pages of description, the clearness with which an author has conceived to himself the necessary results of his own principles. An example of this may be found in Plate XXX., fig. 442 of the first volume, which, as Arago relates, served to demonstrate to him, when he visited Dr Young in 1816, that he and Fresnel had been anticipated on one point more than they believed.[1]

(450.) The absence of algebraic formulæ from this work was as characteristic of Dr Young as their copious introduction into articles which he subsequently contributed to the *Quarterly Review*. He had decided upon writing a book without symbols, and he wrote it, though it gave additional trouble both to himself and the reader.

(451.) We shall now proceed to trace the progress of the undulatory theory of light, the greatest physico-mathematical discovery of our time, in the establishment of which Young acted the leading part.

(452.) The undulatory theory of light—Hooke.

Undulations of Light—Hooke and Huygens.—The idea of accounting for the effects and modifications of luminous impressions by disturbances propagated through a very elastic medium was by no means new at the commencement of the present century. We do not, indeed, attach much importance to the so-called anticipations of Grimaldi and Hooke in the seventeenth century. The former, amongst his valuable experiments on the deflection of light and fringes of shadows, had used an expression as to illumination being diminished by the addition of light, which is true in fact, and is a correct deduction from the law of interference as we now understand it. Hooke, in his *Micrographia*, asserts light to consist in "quick, short, vibrating motion;" but his explanation of refraction by it is altogether erroneous; and his application of it to the doctrine of the colours of thin plates, though admitted by the candid Young to be an anticipation (unknown to him at the time) of his own, has in it no more than a germ of truth (like so many of Hooke's ingenious hints, afterwards claimed by him as discoveries), which yet only explains the fact on which it is founded by means of an additional and gratuitous assumption. The germ of truth in Hooke's writings is this, that the colours in question depend upon a mixture of the light reflected at the first surface of the thin plate with "a kind of fainter ray" propagated from the second surface backwards: the gratuitous assumption is, that "this compound or duplicated pulse does produce on the retina the sensation of a yellow;" why it does so is not explained. This was in 1664, before even Newton was acquainted with the analysis of white light. Hooke's idea that yellow, or any other colour, was the result of the conflict of pulses simultaneously reaching the eye, was an assertion, admissible, perhaps, at that time, as expressing a fact; but surely not a proof of interference producing reinforcement or annihilation of light, as taught by Young. I am not aware that Hooke ever even reiterated his opinions on this subject after Newton had analysed the phenomena experimentally, and shown that the colours of thin plates result from the superposition of bright and dark rings of different prismatic hues, each with its appropriate diameter. It was then apparent that colour was only an *indirect* effect of interference.

(453.) Huygens' *Traité de la Lumière.*

But whatever may be thought of the theories of Hooke, those of Huygens deserve a far more eminent place in history. Having already been succinctly adverted to in Professor Playfair's dissertation, we will only observe that the *Traité de la Lumière* (1690) is an admirably composed and reasoned treatise on the phenomena of light on the undulatory hypothesis. The uniformity of its propagation through the celestial spaces, its rectilinear course in ordinary circumstances, the laws of its reflection and refraction, are there explained with a degree of elegance and precision which ought to have excited (we must think) general attention and assent, but for the ascendancy of Newton's authority, and the astonishing and beautiful nature of the experiments on which his theories were based; whereas Huygens referred to few experiments except those of the simplest kind, and the phenomena of colour were (for good reasons) left chiefly out of view.[2] Such being the case, Huygens may fairly be considered as the author of the undulatory theory, which he supported by such convincing proofs.

(454.) Explanation of simple and double refraction.

The fundamental principle of the Huygenian doctrine was the same as that which Hooke admitted, which was probably far older than his time, namely, that all space, including the interior of transparent bodies, contains an *ether* whose pulsations communicate the sense of light to the eye, as waves in air convey to the ear impressions of sound. To this he added the assumption, that in refracting media, such as glass, the pulsations are *retarded*; whereas in Newton's theory, as is well known, the propagation of light is assumed to be fastest in dense media. The "law of the sines" in refraction, is deduced as a consequence; and one of the prettiest applications made of it is to the phenomena of atmospherical refraction. But the most important features of the whole investigation are these two—(1), the principle that the impression of a wave of light on a screen is to be found by considering the simultaneous effect of the *wavelets* propagated from all the points disturbed at any previous moment (which points form what is called the *front* of a wave). It is only when these partial impressions *concur* that they are strong enough to affect the sense of vision;—(2), the representation of the phenomenon of double refraction by a wave of two sheets, or the simultaneous propagation of spherical and spheroidal waves in one and the same medium. Of the last of these doctrines I shall speak in the next section in connection with the discoveries of Malus. With respect to the former I may here observe that it gives the only satisfactory explanation of the primary difficulty of the undulatory hypothesis,—namely, that a beam of light admitted by a hole in a screen pursues a rectilinear course afterwards, instead of spreading sideways, as do waves in water, and waves of sound. Huygens shows, on elementary and convincing principles, that the lateral impressions of the wave are rapidly extinguished by the want of concurrence of the impulses which they communicate to the ether. This is necessarily true when the breadth of the aperture is such as to exceed vastly the length of a wave; and such is *always* the case with light, but rarely in any other instance. It is, in short, only *immediately* in front of the aperture that the disturbances originating in every part of the front of the original wave embraced within the aperture, concur in producing an accordant movement on the ether.

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[1] The reference of Arago, in his original *éloge* of Young, is to p. 387 of the *Lectures*, obviously by mistake. In the first volume of his (Arago's) collected works it is corrected into p. 787, which is as certainly correct. I have supposed fig. 442 to be more probably the one referred to than 445, to which Dr Peacock refers (*Life of Young*, p. 389).

[2] Nevertheless the Huygenian Theory of Light was propounded as the subject of a thesis at St Andrews by David Gregory, whilst professor of mathematics there, within about a year of its publication (including also the Newtonian doctrine of gravity),—a pleasing proof of the activity which then reigned in that university. Principal Lee possesses the original programme.

(455.) The *principle of Huygens.*

This principle, more fully stated, by which every luminiferous disturbance of the ether is considered as the resultant of all the pre-existing disturbances to which it is due, constitutes what is sometimes called the *principle of Huygens*, of which I shall have more to say hereafter.

(456.) Newton's opinions on the nature of light.

Neither at the time of its publication, nor for more than a century afterwards, was the value of these reasonings understood. It would be beside our present object to discuss Newton's opinions; but it is too certain that he did not allow Huygens' arguments on the undulatory nature of light to have any weight with him. Not that he was averse (as is often supposed) to the presence of Ether as modifying the corpuscular theory of light; on the contrary, in many of his minor writings he speaks of its existence as all but certain, and as a requisite adjunct to the corpuscular hypothesis to which he had been led by the facts of reflection and refraction.[1] But he never adjusted the terms of a compromise, and must be held, we think, to have left behind him no substantive theory of light worthy of the name. The question never perhaps very seriously engaged his attention after the publication of Huygens' book;[2] and we know that about that time his intellectual energies received a shock which left him indisposed for the fatigue of constructing new theories, and still more disinclined to publish them.

(457.) Euler.

Euler, though he professed to defend an undulatory theory of light, treated the subject in a point of view chiefly mathematical, and betrayed that unconcern about physical theories which characterized a mind steeped in geometric abstractions. He even retrograded; for he did not maintain the Huygenian explanation of the cause of definite shadows.

(458.) Young on the undulatory theory—Diffraction.

Young on the Undulatory Theory—Diffraction.—One hundred and ten years after the publication of the *Traité de la Lumière* of Huygens, Dr Thomas Young re-opened the theory of light or "Physical Optics," as he termed it. His experiments and reasonings will be found in a series of papers in the Philosophical Transactions for 1800, 1801, 1802, and 1803.[3] These memoirs are of no great length, and deserve the most careful study. They are perhaps among the clearest and plainest of Young's writings, although blamed at the time for defects precisely the reverse. They are eminently marked by penetration, profound induction, and candour of argument. Starting from his studies in acoustics, the transition to optical questions is extremely gradual. Young was, characteristically, a good musician in practice, as well as a profound one in theory, and his paper of 1799 is principally acoustical. In it he attaches consequence to showing that the divergence of sound from the direction of its emission is slower and less complete than it is commonly believed to be, and he applies the analogy to the existence of *rays* of light and definite shadows. In one short section he sums up the chief points of optical doctrine which lead him to prefer the theory of Huygens to that of Newton. Amongst the facts better explained by waves than corpuscles, we find reckoned Inflection and the Colours of thin plates. But all this is stated in a very general way, evidently rather as a conclusion towards which his mind had for some time been tending, than as the result of demonstrative proofs. In his paper of 1801 the undulatory doctrine is methodically expounded in a series of propositions, accompanied by proofs. The accurate definition of shadows is shown to be possible and natural on that theory, as well as the usual phenomena of reflection, refraction, and total reflection.

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[1] Thus Newton writes in 1675:—"Were I to assume an hypothesis, it should be this, if propounded more generally, so as not to determine what light is farther than that it is something or other capable of exciting vibrations in the ether; for thus it will become so general and comprehensive of other hypotheses as to leave little room for new ones to be invented." And again,—"Do not the most refrangible rays excite the shortest vibrations [of the retina], the least refrangible the largest?"—Birch's *Hist. of the Royal Society*, quoted in Young's *Lectures*, ii. 615, 617. Sir D. Brewster (*Life of Newton*, 1855, vol. i. p. 148) considers that some passages in the later editions of Newton's *Optics* show that he had departed from any theory of undulations.

[2] The *Optics*, though published in 1704, had been written principally in 1675 and 1687 (see Preface).

[3] They may be more conveniently consulted as reprinted in the second volume of his *Lectures on Natural Philosophy*, and in his *Miscellaneous Works*, vol. i.

The partial reflection which always accompanies refraction is strongly and justly insisted on as an obvious consequence of the theory, while it requires a separate hypothesis on Newton's. But the chief weight is claimed for the evidence from the colours of heated surfaces, of thin plates, and of diffracted shadows, all of which the author explains by the mixture of two portions of light conveying to the same particle of ether at the same time either accordant or opposing motions, thus redoubling or destroying the light. Of these the splendid iridescent colours reflected by surfaces having fine equidistant lines drawn upon them, admit of the most elementary and striking explanation. The reflected image of a luminous point viewed in a mirror thus cut up by parallel lines, consists of one common reflection and numerous lateral images which are coloured, and in which the angles of incidence and reflection are *not* equal, thus contradicting one of the axioms of common optics. Young showed that the scattered waves of light recover the faculty of appearing when the surface of the plate is seen under such an angle that foreshortened intervals between the scratches amount severally to the length of one undulation or a multiple of it; for then the waves of light scattered by the reflecting surface will not come *entire* to the eye, but each will have a part systematically suppressed by the non-reflecting space of the groove, so that the remainders being nearly in one phase, *concur* in making a general impression. This experiment, therefore, literally presents us with the paradox that *by suppressing half the light, the remainder is not suffered to be extinguished by it.* The different colours appear reflected at different angles, because the obliquity must vary in order to be accommodated to their several wave-lengths, and each colour undergoes several repetitions corresponding to breadths representing the successive multiples of a wave-length.

Optical paradox.

(459.) The *Eriometer.*

Precisely similar in their origin are the coloured rays scattered by fibrous substances when held between the eye and a small point of light. If they be numerous and all of the same diameter, such fibres will suppress symmetrically portions of waves, and suffer the oblique effect to be perceptible. Dr Young most ingeniously applied this principle to construct an *Eriometer* or measurer of the fineness of fibres. The diffracted light of any order and colour from a distant flame will be seen at an angle with the principal or white image about four and a half times greater when viewed through the down of the beaver, than in the case of Southdown wool; being the inverse proportion of the diameters of the fibres which compose them.

(460.) Fundamental law of interference.

Fundamental Law of Interference.—But the critical and characteristic experiment of interference in its simplest shape was published two years later, in the Bakerian Lecture for 1803.[1] A small hole being made with a needle point in a piece of paper applied to a window-shutter, and a sunbeam being directed upon it by means of a mirror from without, a cone of light is thrown into a darkened room. A slip of card one-thirtieth of an inch wide being held in the sunbeam, its shadow was observed on the opposite wall or on a moveable screen. There were seen fringes of colour exterior to the shadow on each side, such as Newton had described, and on which Mr Brougham and others had made experiments. But besides these, the narrower and less conspicuous fringes seen *in the interior of the shadow*, and first described by Grimaldi, were found by Young to have this remarkable property, that they disappeared the moment that the light passing *either* edge of the card was intercepted, whilst the *exterior* fringe was not at all affected by that circumstance excepting on the side where the light was stopped.

(461.) Diffraction-bands explained.

Young at once perceived the significance of this admirable fact. The existence of light within the shadow at all, was evidently due to the bending of the wave round the opaque edge; but the alternation of light and dark spaces required the union of the two lights from opposite edges, which, immediately behind the centre of the obstacle, must have described exactly equal paths, and therefore united in the same phase; but a little way either to the right or left of the centre the phases were discordant, and complete and effectual annihilation of the light resulted. In fact, when the experiment is performed under favourable circumstances, the *result of the union of the light is perfect blackness in these places*, but if half the light is stopped the dark spaces become luminous!

(462.) Mixed lights produce dark bands.

This splendid paradox may also be demonstrated without any bending round the edges of bodies, and consequently without any inflexion in Newton's sense of the word; and this simplifies the conditions materially. In order to effect this, Fresnel (many years after) produced interference bands by allowing light emitted from a very small luminous point (an image of the sun formed by a lens of short focus) to fall upon two mirrors touching at the edge, and inclined to one another at an angle very little less than 180°. By the common principles of reflection there will be a space beyond the mirrors where the light reflected from the respective mirrors overlaps, and except in a single line within that space, the paths of the two rays meeting in any point will be different. When this difference amounts to a whole number of undulations, an exalted brightness results; when the undulations arrive in opposite phases or the centres of one set of waves concur with the ends of the other, blackness results. The experiment may even be made with a single mirror which a ray of light just grazes, and after reflection mixes with the direct light which had in the first instance passed clear of the mirror.[1] Here evidently we have the required condition of double illumination with difference of paths. The same effect is obtained without either Inflexion or Reflection by refraction through an excessively flat prism.

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[1] *Miscell. Works*, vol. i. p. 179.

(463.) Length of the waves of coloured light.

It is an easy matter (comparatively) to assign the lengths of a wave of light, from the intervals of the interference lines, or still better from the elongations of the coloured images produced by striated surfaces, the intervals of the striæ being given. Newton's measures of the intervals between the lenses producing coloured rays, gave Dr Young the following for the number of undulations contained in an inch producing each colour:

Extreme Red	37,640
Boundary Red and Orange	40,720
... Orange and Yellow	42,510
... Yellow and Green	45,600
... Green and Blue	49,320
... Blue and Indigo	52,910
... Indigo and Violet	55,240
Extreme Violet	59,750

Now the velocity of light is known, that is, the rate of propagation of a disturbance in ether; but the duration of an impulse, or rather the interval between two successive impulses striking the eye and producing the effect of colour, is the time that an impulse takes to travel over the length of a wave. It is easy to see how almost infinitely short this must be: 460 millions of millions of such impressions in a second of time go to make up the sensation of redness, 735 millions of millions that of violet light.

Number of vibrations in a second.

(464.) Opposition to Young's views.

It might be supposed that Young's discovery and its application excited the notice and applause of all persons interested in optics. This was very far from being the case. Though he brought it several times in succession and in different forms before the Royal Society of London, there is no evidence, so far as I at present know, of his having then obtained a single adherent. Davy was no optician; Wollaston was too cautious to commit himself, though probably giving a tacit assent; Cavendish was aged, and besides had attended less to this subject than to most others; Sir William Herschel had only lately taken up physical optics, and that with reference to the qualities of the spectrum least connected with Young's observations. At the Royal Institution Young vainly attempted, in the elaborate course of lectures which he there delivered for two years (1801-3) on natural philosophy and the arts, to arouse a popular interest in the unveiling of these mysteries. The abstruseness of his discourses scared that mixed audience, and his colleague Davy, in a letter, incidentally observes that Young would be satisfied if any one would even offer criticisms on his opinions. Criticism of a certain kind, however, he soon got in abundance. The *Edinburgh Review*, in its second number, undertook to crush at once the theory of Young and his reputation as a philosopher, and this (in singular contrast to its avowed principles), not by argument, but by an appeal to the weight of prescriptive authority in favour of the Newtonian hypothesis, concluding with an admonition to the Royal Society to cling to its old standards and old celebrities, and to save its Transactions from degenerating into volumes of miscellanies. This attack, paltry as it was, seriously prejudiced the reception, or even the dispassionate consideration of Young's views. His anxious vindication put forth in a separate pamphlet was unread, and the doctrine of interference was first understood and relished in France ten years later.

(465.) Theory of the rainbow incomplete without the doctrine of interference.

Theory of the Rainbow.—It is a matter of interest in several points of view that the phenomenon of the rainbow, which gave the first suspicion of the varying refrangibility of light, and which, when explained and reduced to calculation by Newton, so convincingly proved the truth of the doctrine of the composite nature of white light, was destined in the hands of Young and of his successors to yield one of the most refined evidences of the extensive application of the doctrine of interference. The general fact of the arrangement of colour in the primary and secondary bows Newton accounted for. But the *spurious* or supernumerary bows occasionally seen *within* the primary, and far more rarely *beyond* the secondary, consisting of reddish and greenish bands, remained unexplained. The brilliancy of any given portion of the rainbow depends upon the deviation of the sun's rays by two refractions and one reflection, approaching to a limit which it cannot overpass. But except at this precise limit an amount of scattered light will reach the eye, which, though not reflected under the most favourable circumstances, yet is still sufficiently intense to be visible. This light must be composed, as Young showed, of two portions, entering the eye in the same direction, but which have pursued different paths within the drop, and which never coincide except at the extreme geometrical limit before mentioned. When one of these paths differs from the other by the length of half a wave of the particular kind of light considered, darkness will result, but a feebler maximum will be again attained when the interval rises to a whole wave-length, or to two or more. Hence these consequences follow—*first*, that the bright part of each colour is limited by its self-destruction to a narrow band, and thus the purity of prismatic colour so striking in a well-formed rainbow is preserved; *secondly*, that each colour may attain (by interference) a second and a third maximum, corresponding in fact to the position of the spurious bows; *thirdly*, that these phenomena of perfect definition of the primary and secondary bows, and of repeated maxima in the supernumerary bows, depend essentially on this condition, *that the drops of falling rain shall approach to*

Spurious bows.

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[1] This experiment is usually (and justly) ascribed to an eminent and amiable British philosopher. But it had already been performed by Fresnel with a special object. See *Ann. de Chimie et de Physique*, second series, xv. 382.

a general equality of size. For the effects of interference depend on the precise diameter of the drop; if these be very various the resulting positions of maxima and minima will be altogether confused. Dr Young pointed out that to accord with the phenomena the falling drops must be about $\frac{1}{70}$ of an inch in diameter.

(466.) Delicacy of the phenomenon of the rainbow as a test of Theory.

I have merely indicated the nature of an argument of extreme interest and beauty. It would be difficult to cite (except perhaps in the science of physical astronomy) a more complete specimen of gradual inductive research. Here is a phenomenon—the rainbow—as familiar as it is beautiful. Even a partial insight into its cause confers a certain reputation upon one individual (De Dominis), its farther explication gave Newton one of his most popular triumphs. It is then found that the rainbow is not so simple a fact as was supposed, and that Newton's theory accounts for only its broader features. Then, as in the theory of gravity, a long period of uncertainty ensues; but observations are continued. A *perfect* rainbow is found to be one of the rarest of natural phenomena, instead of the commonest. Not above two or three individuals have ever seen, or at least described one. Then comes Dr Young, with his theory of interference and diffraction. This theory not only accounts for the spurious bows, but for the precise appearance of the principal ones, which, but for it, would have been different from what Newton supposed. Finally, after being canvassed for more than two centuries, the theory of Young is carried out into its rigorous consequences by Mr Airy[1] and Professor Stokes[2] (who must first invent a new mathematical method for the purpose) and illustrated by the ingenious experiments of M. Babinet and Professor Miller;[3] until at last we begin to believe that we understand this matter completely.

(467.) Exterior fringes of shadows;

Exterior Fringes of Shadows.—I have mentioned only generally Young's application of his theory to the coloured fringes observed by Grimaldi and Newton to surround the outline of bodies, as thrown in shadow by a luminous point upon a distant screen. I have done so because Young's explanation was imperfect, not to say incorrect. But as it would be inconvenient to discuss the subject here, I shall briefly indicate its history and result. Dr Young expresses himself more obscurely in his paper of 1801 on this point than on any other, indicating three possible explanations. In 1803, however, he distinctly adopts the opinion that the periodical colours in question are due to the interference of direct light passing *near* the opaque edge with a portion of light very obliquely reflected from that edge; and he enters into calculations to show that such a theory represents sufficiently well Newton's measures. But it is unaccountable that Young should have been satisfied with the belief that the screens employed should in *every* case have reflected an appreciable quantity of light (or indeed any light at all) in the required direction. It might be conceivable in the case of a cylindrical wire or a cylindrical hair; but how could a film of gold-leaf or a slip of paper receiving the light on its broad side furnish such a degree of oblique illumination? It is wonderful that Young's intuitive sense did not perceive that the portion of a luminiferous wave passing near an opaque edge, is deficient on one side of the interfering wavelets which are necessary to make the boundary of the shadow definite, and to extinguish the laterally-spreading light. In short, he did not allow to Huygens' principle (see art. 455) the full breadth of its application—a discovery made some years later by Fresnel, who has the credit of first explaining these exterior fringes.

(468.) full explanation of them due to Fresnel.

That great philosopher (the worthy rival of Young in this career of discovery) found the means of computing, on strict geometrical principles, the *sum total* of the disturbance produced at any point of a screen by the whole effective portion of a luminiferous wave partially stopped by an obstacle of a given form. The principle of the calculation is simple enough. The origin of the light being distant, the front of the wave is considered as flat when it breaks against the opaque body. Its front is then divided (in thought) into small elementary portions, each of which is considered as the source of a disturbance propagated as from a new origin. The effect of each wavelet is calculated in terms of the co-ordinates of its origin, and of the point where its effect is to be considered. The sum of all these simultaneous effects is collected by integration, a process which unfortunately is only rigorously possible in a limited number of cases. Some of these cases were solved with great ingenuity by Fresnel, and compared with observation. The result was extremely satisfactory. Yet it is curious to observe that Young's explanation, if it had had a sufficient physical basis, leads to *nearly* similar results. In the case of an indefinite opaque body with a straight edge, the illumination precisely at the boundary of the "geometrical" shadow is, on Fresnel's theory, *one-fourth* of what it would have been were the body removed. *Within* this line the light dies away gradually, having no maxima or minima. *Without* it, a series of dark and light bands occur, which rapidly blend into a uniform illumination. The same theory leads to results as to the position of the interior bands which are also somewhat different from the simpler calculation of Young, and still more conformable to experience. Amongst the most singular of these results is this (which is perfectly confirmed by observation), that the shadow of a small round opaque body (as a spot of tin foil) is illuminated by a speck of diffracted light at its centre precisely as bright as if the disk were removed! How, after this, can we talk of light as moving in straight lines only?

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[1] Camb. Trans., vol. vi. (1838.)

[2] *Ibid.*, vol. ix. (1850.)

[3] *Ibid.*, vol. vii. (1842.)

(469.) Young's farther researches chiefly anonymous.

His articles in the *Quarterly Review*, and *Encyclopædia Britannica*.

We must now advert to the peculiar and disadvantageous manner in which Dr Young laid his farther researches before the world. The optical papers in the *Philosophical Transactions*, ending with 1803, were the last which he published connected with his theory in that work, although he continued to be Foreign Secretary until his death twenty-five years afterwards, and although during all that time he never ceased to extend and perfect his views on the subject of his predilection. The explanation of this paradox is to be found principally in the strictness with which he interpreted the allegiance which he owed to the medical profession. He had determined to be a practical physician; his early principles of action prevented him from doing anything by halves; and all experience affirmed, that to gain confidence as a physician in the metropolis he must cultivate sparingly, and as it were by stealth, the studies of abstract science and of philology in which he delighted. Unquestionably he was also disgusted by the absence of one single supporter amongst the members of the great society referred to,—by the injurious petulance of the then popular critical journal,—and by the impossibility under which he laboured of communicating orally his knowledge to a general audience in an interesting and acceptable manner. The result of all this was the suppression of many of his opinions, and the publication of others in so concealed and uninviting a form that they remained for years nearly buried and unknown to men of science. He contributed a series of articles on subjects connected with light to the *Quarterly Review;* and we may well smile at the abstruse and really obscure dissertations on detached points of science—often unmercifully loaded with algebra—thus interspersed with articles of popular criticism for the entertainment of the reading public. From some of these papers we may readily gather the soreness which he felt at the cold reception of his discoveries. Farther and still more important original speculations were contained in a series of anonymous papers (sixty-three in number) on a vast variety of subjects, both in science and philology, contributed to the *Encyclopædia Britannica.* It is not in a work such as this that we usually look for the *first* publication of great and original views: the articles being anonymous could only very gradually attract notice by their intrinsic merit; and the obscurity of some of those written by Young rendered this difficult enough. But it is most fortunate that he was induced thus to write: many of his most original thoughts must have been lost but for these concealed repositories. In the articles in the *Quarterly Review*, for example, we watch with interest the impression which contemporary discoveries made upon his mind. The spheroidal wave of extraordinary refraction is explained by unequal elasticity of the crystal in different directions;[1] the discovery of polarization by reflection is received with characteristic candour, as giving a temporary blow to the undulatory theory;[2] whilst in a later paper the cause of chromatic polarization is convincingly deduced from the principle of interferences, and in the space of two lines the peculiar coloured laminæ occurring in Iceland spar, which had been noticed by several experimenters, are accounted for.[3]

(470.) Theory of polarized light deferred to § 3.

From about 1815 the optical discoveries of Young were so intimately connected with those of his younger friend and rival Fresnel, that it seems best to defer our account of them until we consider (in § 3 of this chapter) the peculiar researches of Fresnel, which ultimately rendered the phenomena of polarization the most impregnable position of the partizans of the undulatory theory. The first great step was the conception of *transverse vibrations* of ether, as constituting polarization. This, as we shall see, was first *published* by Young. It is to be regretted that the tardy and imperfect publication of Fresnel's memoirs on the one hand, and the resolution of Young to adhere to an anonymous and indirect mode of announcing his discoveries, on the other, render the history of the subject sometimes obscure. The correspondence between them, first fully published by Dr Peacock, throws some light upon it; but several important letters have not been recovered.

(471.) Physiology of vision; interpretation of hieroglyphics.

I had intended devoting a portion of this section to Dr Young's important and ingenious researches on the physiology of vision. But the length to which it has already extended obliges me reluctantly to omit it. I also refer to the chapter on mechanics (Art. 344, &c.) for some notice of his masterly reasonings on the principles of carpentry and the flexure of elastic substances. They are characterized by directness of purpose and a consummate command of ordinary mathematics, unaccompanied by any pretension to symbolical display;—it might be added too, by the obscure conciseness of Dr Young's habitual style. His researches (preceding and anticipating those of Laplace) on capillary attraction have also been referred to (432), as well as his masterly investigation of the tides (80, 81). It does not belong to this treatise to speak of his discovery of the interpretation of hieroglyphics in certain cases which gave the first real impulse to this obscure but interesting subject. The successes of Champollion, Rawlinson, and others, in similar undertakings, must logically be connected with the first great step of decyphering the polyglot stone of Rosetta. It may safely be affirmed that no philologer ever before made such a discovery in science as the law of interference, and that no natural philosopher ever made such a step in the interpretation of a lost tongue as the formation (up to a certain point) of an Egyptian alphabet.

(472.) We cannot close this imperfect sketch of one of the greatest ornaments of our age and nation, without

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[1] *Quart. Rev.*, vol. ii.

[2] *Ibid.*, vol. iii.

[3] *Ibid.*, vol. xi.

Young's personal character, and death.

adding, that in private life Dr Young was exemplary; endued with warm affections, philosophic moderation, and high moral and religious principles. His office as secretary to the Board of Longitude (the only public promotion he received), was attended not only with immense labour in editing the Nautical Almanac, but with vexatious contentions, which in his, as in so many other cases, tended to diminish his usefulness and even shorten his life. To the petty persecutions with which he was assailed, it was owing that the health which the unbroken study of fifty years had not impaired, at length gave way, and he died yet in the prime of intellect, the 10th May 1829, within a few months of his honoured associates and friends, Wollaston and Davy. He had been elected two years previously one of the eight foreign associates of the Academy of Sciences of Paris.

(473.) Philosophical character.

Dr Young's philosophical character approached in many important particulars to that of Newton. With much of the inventive fire of Davy, and of the reasoning sagacity of Wollaston, he combined an amount of acquired learning, and a versatility in its application, far superior to both. We do not ascribe to him an intuitive insight so rapid and almost divine as that which distinguished the author of the *Principia* above all other men, nor had Young the same strictly mathematical ability; but like Newton, whatever he did was practical and sound; nothing was done for show, nothing omitted through haste. "The power of patient thought" was the lever with which he moved the world. His self-confidence was great but unobtrusive. He attained, as he himself said, all the main objects to which he had looked forward in life, "such fame as he valued, and such acquirements as he might think to deserve it."

§ 2. Malus.—*Discovery of the Polarization of Light by Reflection.—Early History of Double Refraction and Polarization.*

(474.) Malus—the polarization of light.

Etienne Louis Malus was born at Paris on the 23d July 1775, and died on the 24th February 1812, after a too brief but brilliant career. His principal discovery, that of the polarization of light by reflection, is so intimately connected, both historically and by the nature of the case, with double refraction, that I shall briefly sum up the scanty progress of that singular subject previous to his time.

(475.) Early history of double refraction—Huygens' law.

It was known to Bartholin of Copenhagen, about 1669, that Iceland or calcareous-spar has the property of dividing a ray of light, which falls upon it in almost any direction, into two; one of which is refracted according to the usual law, but the other in an extraordinary manner, which was first analyzed by Huygens—a problem of great difficulty, in which Newton not only failed, but he also erred in continuing to pronounce Huygens' solution false. The solution was this, that there is one direction in the crystal parallel to which both the rays (called the *ordinary* and the *extraordinary*) move in a similar and uniform manner. In other directions their propagation may be expressed by considering the ordinary ray within the crystal to be due to a spherical wave (the centre of which coincides with the point of incidence), whilst the extraordinary ray corresponds to a flattened spheroidal wave concentric with the former, and having its axis coincident with a diameter of the sphere, and parallel to the mineralogical axis of the crystal. Both rays, on the Huygenian hypothesis, move slower than in air, but the extraordinary ray everywhere faster than the ordinary ray, excepting only in the axial direction. A perfectly plain though necessarily complex construction was given by Huygens for the purpose of tracing both rays in the course of their refraction, founded on this idea.

(476.) Confirmed by Wollaston;

Newton's opposition to Huygens' law as a statement of fact left it for more than a century under partial doubt. Haüy is stated to have verified it, or at least to have shown that it approached nearer to the truth than Newton's; but Dr Wollaston first reestablished it in 1802 by conclusive experiments, which, however, he found it impossible to connect by a law until the previous generalization of Huygens had been pointed out to him,—most probably by Dr Young.

(477.) and also by Malus.

It was several years later that Malus directed his attention to the subject, unaware of what had been accomplished by Wollaston. He had returned in 1801 from the unfortunate French expedition to Egypt, where he was engaged as an officer of engineers, and had ruined his health through fatigue and the insalubrity of the climate. He was an accomplished mathematician, having acted as professor both at the Polytechnic School and that of Metz, and was of course a member of the Institute of Cairo. On his return to France, during the intervals of his military duties, he occupied himself in the composition of an elaborate analytical treatise on optics, which had already occupied his attention in Egypt. This led him to the subject of double refraction, and he verified by numerous experiments the accuracy of Huygens' law. La Place wrote a paper on the mathematical law of the velocity of the extraordinary ray, in which he introduced the idea of a repulsive force emanating from the axis of the crystal; but it may be truly affirmed that the notion of a spheroidal undulation so happily introduced by Huygens is the only one which really fits the case; and by the very impossibility of expressing the facts intelligibly without it, gives an undisputed advantage to that theory.

A prize having been proposed by the Academy of (478.)

Essay on double refraction.

Sciences for the theory of double refraction, Malus wrote a second paper, which was crowned, but which, however admirable as a specimen of mathematical address, added little to what was previously known.

(479.) Huygens' discovery of polarization by calc spar.

Malus had already, in the end of 1808, announced a property of light which, if not absolutely new, was entirely so with reference to the circumstances in which it was produced. The polarization of light was in reality discovered by Huygens previous to 1680. He had observed that the two rays into which common light is divided in passing through Iceland spar have a singular diversity of character, which Newton afterwards described as an opposite polarity. Huygens showed that if two rhombs of doubly refracting spar are laid symmetrically one upon the other, the "extraordinary" ray yielded by the first is extraordinarily refracted by the second, and the "ordinary" ray from the first is ordinarily refracted by the second. But when we revolve the upper rhomb as it lies upon the lower one through a right angle, a remarkable change appears. The extraordinary ray escaping from the first is now ordinarily refracted by the second, and *vice versa*, so that the qualities of the two rays differ but only so far as this, that either may be assimilated to the other by making it (or the crystal from which it derives its properties) revolve round ninety degrees. A definite notion of such a distinction may be formed by imagining a musical string vibrating at one time in a vertical, at another in a horizontal, plane. If we could possibly imagine light to consist of vibrations of this description, the two rays of Iceland spar might be conceived the one to vibrate in a plane passing through the axis of the crystal, the other in a plane perpendicular to that. Such light might truly be said to have acquired the property of *having sides*. In the language of Newton, it is *polarized*.

(480.) Malus discovers polarization by reflection.

The discovery of Malus consisted in showing that light may acquire properties identical with those of either ray yielded by refraction through Iceland spar, by the very simple process of simple reflection at a particular angle from any transparent body. Thus for a surface of water he found this angle to be 52° 45′ with the perpendicular, and for glass 54° 35′. The reflected light in either case has exactly the property of the ordinary ray transmitted by a crystal whose principal section (that is, a section passing through the axis of the crystal) is parallel to the plane of reflection. Consequently this light will be acted on by a doubly refracting crystal placed in its way precisely as if it had emerged from a similar crystal; and, on the other hand, if the two rays emerging from a crystal be incident on water or glass as above mentioned, the one will be copiously reflected from the surface, whilst the other will not be reflected at all, but pass entirely into the transparent substance. Farther, as might be expected, light thus polarized by reflection, when it falls on a second similar reflecting surface at the same angle as before, will be copiously reflected if the planes of reflection coincide, but will refuse to be reflected in an appreciable degree when the planes of reflection are perpendicular.

(481.) Occasion of it.

This phenomenon was detected by Malus by casually observing that a ray from the setting sun reflected from a distant window, and viewed through a piece of Iceland spar, afforded but a single image in two positions of the latter. The experiment attracted universal attention, and became the germ of a series of optical discoveries almost unprecedented for their beauty and variety; yet most of the experiments may be made quite as well when light is polarized by the method of Huygens as by that of Malus. Nevertheless the former had remained a sterile fact for 130 years. Upon such trifling circumstances does the progress of knowledge often depend.

(482.) Law of the cosines.

Malus survived his discovery only four years, and saw but the borders of that land of promise which he had pointed out to others. A few results he however obtained, which are worthy of notice. Thus he found that in every instance where light is polarized in any plane there is also produced a certain proportional amount of light polarized in the perpendicular plane. Arago afterwards proved the very important fact, that these two portions are universally *equal*. Huygens had shown in the experiment of the two rhombs, that when their positions are neither symmetrical nor perpendicular, each ray emerging from the first is duplicated by the second. When the principal sections of the rhombs are inclined 45°, the duplicated rays are equally bright; as they approach parallelism or perpendicularity, one pair of the rays brighten and the other pair is enfeebled. Malus ascertained the law of change of brightness, which is the same for rhombs of spar or for plates of glass whose planes of reflection vary whilst the angle of reflection remains constant. In either case the intensity of the light varies as the square of the cosine of the angle formed by the principal sections of the crystals or the planes of reflection of the plates. This important law, the best established in photometry, has been applied by Arago to the measurement of light in many instances, but the details were unfortunately not made public before his decease.

(483.) Other discoveries.

To Malus is also due the discovery of the polarization of light by common refraction. When light is incident on glass or water, the refracted beam contains precisely as much polarized light as the reflected beam, but oppositely polarized. The metals were at first believed by Malus to polarize no appreciable quantity of light. He afterwards found that at great incidences the reflected light is partly polarized.[1] He likewise ascertained the fact of the "depolarization" (as it was termed) of light by many crystals, and also by organized substances, such as hair, horn, and whalebone. He does not appear to have noticed the phenomena of colour accompanying such depolarization, though he arrived at it so nearly that Arago, in all probability, anticipated him by presenting a memoir on the subject to the Institute just one week previous to Malus's announcement of what he had observed (19th August 1811). In less than six months later Malus was no more.

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[1] See an interesting letter from Malus to Dr Young in Thomson's *Annals*, vol. iii.

(484.) Character of Malus.

The writings and discoveries of Malus present evidence of great talent, but of far less fertility of combination than those of Fresnel, presently to be noticed. He maintained the Newtonian theory of light. His reputation amongst his intimates was extremely high, and it was generally believed, that had he survived, his discoveries would have extended much farther. To him was applied Newton's saying on the death of Cotes,—"If Cotes had lived we should have learned something."

§ 3. Fresnel.—*The Undulatory Theory of Light continued.—Diffraction.—Transverse Vibrations;* Young.—*Polarization and Double Refraction explained.—Lighthouse Illumination.*

(485.) Fresnel.

Augustin Fresnel was born at Broglie, in France, 10th May 1788, of a feeble constitution, and he continued throughout his too short life a prey to attacks of bad health. As a boy, his slow apprehension and uncertain memory gave no indication of the maturity of his judgment. He entered first the Polytechnic School, then that of *Ponts et Chaussées*. His fidelity to the Bourbon cause occasioned his being harshly treated by Napoleon, and he retired to Normandy in the beginning of 1815, to pursue the scientific studies which he had always loved.

(486.) Diffraction of light. Fresnel's first memoir.

Diffraction.—The theory of light in particular attracted his attention, and he had a steady belief that the Newtonian doctrine was erroneous, though in ignorance, as it appears, of the undulatory doctrines of Hooke, Huygens, and Young. The phenomena of diffraction, or the coloured fringes which are seen in the interior of the shadows of opake bodies when illuminated by a minute source of light, attracted his attention as most proper for deciding the delicate question of the molecular or undulatory character of light. The results of his experiments were detailed in a memoir confided in the first place to his friend Arago, and by him communicated to the Institute of France (October 1815). This remarkable paper contained much which Dr Young had already discovered, and the explanations of the experiments which it described, both new and old, by the theory of undulations, were common to both. Dr Young having anticipated the publication by at least a dozen years, there could be no question of priority; but it is equally certain that Fresnel was unaware of what Young had done until it was pointed out to him by Arago. His memoir, which was published in great part in the *Annales de Chimie* for 1816, contains much which is interesting. The mode of observing the diffraction bands *directly* by means of a lens, without the intervention of a screen, was equally new and important. The observation that the *interior* fringes of the shadow of a narrow body, such as a wire, disappear when the light is intercepted on either side of the wire, leading to the conclusion that the union of the light from *both* sides is necessary for their occurrence, was (as we have seen) one of Young's capital experiments. The explanation of Newton's rings, by the interference of the light reflected from two adjacent surfaces, though partly anticipated by Hooke, was equally important. Numerous measures of the distances of the exterior diffraction bands from the geometrical shadow, as formed by homogeneous red light, are then given and compared with theory. Here Fresnel was on original ground. These accurate numerical comparisons, afterwards pursued to a greater extent, constituted one of the most important bases of the new theory. In obtaining them he was materially aided by Arago, who, though considerably his senior, generously assisted him in every respect, and gave him the full advantage of his station as a member of the Institute, and of his experience.

(487.) Second memoir. Improves upon Young's theory.

Fresnel's first memoir on diffraction justly excited so much notice that the subject was proposed by the Academy of Sciences in 1817 for one of their prizes. The new essay which Fresnel then wrote was, as probably had been anticipated, the successful one. In this memoir he made an important step, by showing that the *exterior* fringes in diffraction shadows do not depend (as Young had supposed) upon the interference of the direct light with that reflected at a great obliquity from the edge of the diffracting body, but from the interference of the different elementary undulations which proceed from the disturbed surface forming the front of the grand wave. Decomposing the front of the wave into small portions after the manner of Huygens, he computed the disturbance produced by the integral effect of the whole at a given point of the screen where the picture of the shadow fell and was submitted to examination, and he found that such integral effects have a periodic character, presenting points of maximum and minimum disturbance, or of greatest and least illumination as we recede from the geometrical shadow. These distances being measured in homogeneous red light were found to agree with the results of an arduous computation, requiring, as will easily be seen, an intimate acquaintance with the integral calculus and much skill in using it. Such Fresnel possessed, though he always refers with great modesty to his limited facility of employing the higher mathematics.

(488.) Transverse vibrations—Young and Fresnel. *Transverse Vibrations—Young and Fresnel.*—Considerable obscurity hangs over the first publication of this important discovery. A clear and impartial abstract of the facts will be found in the second volume of Dr Whewell's *History of the Inductive Sciences*, and some further documentary evidence, including interesting letters which passed between Young and Fresnel, have more recently been published in the Life and Works of the former, edited by Dr Peacock. The difficulty of apportioning the credit between Young and Fresnel partly arises from the unfortunate system of imperfect publication, or non-publication, adopted on professional grounds by the former, and partly from the grievous delays imposed upon the latter by the opposition with which his opinions and experiments were received at the French Academy of Sciences. This continued to the very close of Fresnel's career. His greatest work was not published in the *Memoirs of the Institute* until six years after date; another was mislaid for above twenty years, and even the hardy friendship of Arago sometimes almost recoiled before the storm of opposition which the novelties of his associate were sure to excite in the minds of the dominant mathematical section. It is quite impossible to say precisely at what period Young first imagined that the differences of oppositely polarized rays of light might be explained by perpendicularity in the directions of vibration of the ethereal molecules, which he compared to the vibrations of a cord in which the elementary movements are at right angles to the direction of wave-propagation. It seems evident that Young was not possessed of this idea in 1814, when he partly explained depolarization in a few pages of an article in the *Quarterly Review*. It is equally certain that he announced it to Arago (with whom he became personally acquainted in 1816) in January, 1817; and that he then speaks of it as an idea which apparently had recently occurred to him, most probably since their interview.[1] Arago and Fresnel had already, in 1816, made experiments demonstrating *that rays oppositely polarized do not produce dark bands by their interference*, a memorable discovery, requiring very great nicety for its satisfactory proof, which, however, was completely attained. It was this observation which (naturally) gave Fresnel the first idea of transverse vibrations, and it is much more than probable that Young worked out a similar solution of the great problem, in consequence of the account of these experiments which he received from Arago in the summer of 1816.[2] Be this as it may, Young and Fresnel unquestionably imagined the theory separately, but Young first announced it, Fresnel being discouraged by the doubts of Arago, and by his awe of the Institute. As clearly, the experiment of non-interference was the first which gave a colour to so bold an assumption, and in the details of its application to double refraction Fresnel had the undivided merit. What is not least worthy of notice in the affair, is that neither of the amiable rivals (Young and Fresnel) ever published a word in disparagement of the other, nor a single unfriendly reclamation of priority.

(489.) Applied to the theory of light. The doctrine of transverse vibrations being allowed, its applications and severest tests were twofold, 1st, To the phenomena of ordinary reflection and refraction including the polarization produced by these operations; and 2dly, to double refraction and the universally concomitant polarization. In these bold speculations and laborious inductions, Fresnel was nearly alone. Young did not appear as a competitor; even his friend Arago, though sympathizing with and proud of his success, was not associated with him.

(490.) Laws of reflection and refraction—Fresnel. *Laws of Reflection and Refraction.*—With regard to the reflection and refraction of light, its intensity has to be defined, and also its condition as to polarization. The fundamental laws of the *direction* of the rays are not affected by this theory. Rigorous mathematicians who then doubted the possibility of transverse vibrations having more than a transitory existence, if they existed at all, could not be expected to supply the theory of their reflection and refraction at the bounding surfaces of different media. Fresnel, however, guided by probable mechanical analogies, with an intuitive insight worthy of Newton himself, gave a formula for the intensity of reflected transverse vibrations, both when the plane of vibration of the molecules is in the plane of reflection, and when it is perpendicular to it; and he conceived common light to act as if equally composed of both sets of vibrations. His formulæ embrace the non-reflection of polarized light at the critical angle, under the circumstances explained in the last section. It is a most remarkable fact that these inferences by Fresnel as to the numerical relations of the intensity of the reflected to the incident light through all angles of incidence, anticipated almost every trustworthy photometrical measure; and from their singular though indirect accordance with many phenomena, they have been generally accepted as an expression of a natural law of great complexity, even by those who were not favourable to the theoretical views on which they are based.

(491.) The modifications of the state of polarization of light which takes place by reflection, was equally

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[1] "I have also been reflecting on the possibility of giving an imperfect explanation of the affection of light which constitutes polarization, without departing from the genuine doctrine of undulation." He then refers to "a transverse vibration propagated in the direction of the radius, the motion of the particles being in a certain constant direction with respect to that radius; and this," he adds, "is a *polarization*."—Young's *Miscell. Works*, vol. i., p. 383.

[2] Peacock's *Life of Young*, p. 390.

Circular polarization.

embraced in Fresnel's theory, and equally (though unknowingly) confirmed by Sir D. Brewster's laborious observations. But on one point Fresnel himself obtained a signal triumph. Having deduced expressions for the intensity of refracted light, on pushing them to the limit where refraction out of a denser into a rarer medium becomes impracticable because the light undergoes total internal reflection, the formulæ became affected by the multiplier $\sqrt{-1}$, and were unsusceptible of arithmetical evaluation. In endeavouring to attach a meaning to these expressions, it occurred to him that as the *intensity* of the totally reflected ray undergoes no change with the angle of incidence, the expression in question might in some way determine the alteration of the *phase* of the wave (the position and direction of motion of the molecules under consideration) which took place at the instant of reflection. Now, admitting this as likely, it appeared that the phase would vary not only with the angle of internal reflection, but with the plane of polarization of the ray. It had previously been shown by Arago and by himself, that when two *oppositely* polarized rays meet or interfere, though there is then no destruction of the light, there is usually a remarkable change in its character. There is one position of the interfering wave relative to the primary one in which the combination produces light polarized in a plane exactly intermediate between the planes of previous polarization. If either ray be now accelerated by *half* a wave-length on the other, the new plane of polarization becomes perpendicular to the former; but if the shift of either of the primary rays amounts to only *one quarter* of a wave-length, the motion of the molecules takes place in a circle, and the undulation has a helical form. Now, Fresnel tested his hypothesis concerning totally reflected light by calculating the circumstances of incidence which should produce an effect equivalent to this; and the result completely verified his bold conjecture. The apparatus employed is called *Fresnel's Rhomb*, which transforms plane-polarized light into light equally reflexible in all azimuths, yet not common light, because it possesses properties which common light does not (such as displaying the rings in crystals); this is termed circularly polarized light.

(492.) Double refraction explained.

Theory of Double Refraction.—The difficulty of accounting for double refraction did not consist in showing how a spheroidal wave might be propagated. Young had already shown, in 1809, that it would result from supposing a lamellar arrangement of the crystalline molecules so that the ether was differently elastic in a direction parallel to the axis than in a plane or planes perpendicular to that line.[1] Huygens had shown something similar in accounting for terrestrial atmospheric refraction. The difficulty was, to account for two waves travelling at the same time through the same portion of matter with unequal velocities. The moment that the idea of molecular movement *transverse* to the line of propagation was admitted, it was easy to see that no contradiction was involved in the idea. Two waves might simultaneously travel in the same direction, and through the same medium, provided the molecular displacements were in different planes. So happy a solution could hardly fail to strike such minds as those of Young and Fresnel with the impress of conviction. A closer analysis confirmed the probability. Iceland spar (or rather the ether imprisoned within it) is conceived of as a medium of uniform elasticity in all planes perpendicular to the axis, but of a different and greater elasticity in any direction parallel to the axis. It is shown to result from this, that in the direction of the axis alone is the motion of light independent of the plane of the vibrations of which it is composed, and consequently no separation of rays occurs. When a ray moves parallel to what may by an analogy be called the equatoreal plane of the crystal, its undulation will, generally speaking, be resolved into two whose vibrations are parallel and perpendicular to that plane, and which travel with different velocities though in the same direction. If the ray take any other direction through the crystal, both the direction and velocity of the divided rays differ. The form of the extraordinary wave is exactly the spheroid of Huygens.

(493.) Theory of crystals with two axes,

But what are we to conclude concerning those crystals (of the discovery of which we shall speak in § 5) presenting two axes of double refraction? Fresnel at once assumed that the elasticities must in that case vary in *three* rectangular directions, and he proceeded to calculate the manner of propagation of a wave through a medium thus constituted. I had proposed to attempt some explanation of the steps of his most ingenious and profound argument, but I find it incompatible with the space at my disposal, and at any rate hardly to be apprehended without the use of symbols or figures. For these reasons I shall merely state the results. When the medium presents unequal elasticities in three rectangular directions, the surface of the wave consists of two sheets each travelling with its peculiar velocity. But neither of these being spherical, the result cannot be expressed by the ordinary law of refraction. In *two* directions within the crystal, the wave surfaces coincide, or the two rays coalesce. These directions are evidently the optic axes, and the wave surface in their neighbourhood has very interesting geometrical and physical properties which have been elucidated by British philosophers, as will be noticed in another section. The true optical axes cannot exceed two, and when two of the three elasticities become equal, they merge into one. This is the case in Iceland spar and similar crystals. At the same time the wave surface degenerates into the united sphere and spheroid. The equation to the wave surface was deduced by Fresnel in an indirect and somewhat tentative manner. It was demonstrated by Ampère directly, but inelegantly. M. Cauchy, Mr Archibald Smith, and Professors Sir W. R. Hamilton and Maccullagh gave more complete and elegant solutions.

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[1] Young's reasoning (*Quarterly Review* 1809, and *Works*, vol. i. p. 228) is based on an experiment by Chladni on the differing velocity with which sound is propagated in wood, depending on the direction of the fibres.

(494.) confirmed by experiment. Fresnel submitted his theory (as usual) to experiment. He found that in topaz, which is a biaxial crystal, neither ray follows the law of common refraction. The plane of polarization (which is always perpendicular in the two rays) follows very nearly indeed, by theory, the law which M. Biot had assigned by experiment. Fresnel thus stated the ground of his conviction of the truth of his theory, and it would be difficult to express more appropriately the characteristics of a just hypothesis:—"The theory which we have adopted, and the simple construction which we have deduced from it, present this remarkable character, that all the unknown quantities are at once determined by the solution of the problem;—the velocity of the ordinary and extraordinary rays, and their respective planes of polarization. Physicists who have studied with attention the laws of nature, will admit that this simplicity and these intimate relations between different parts of the same phenomenon present a great probability in favour of the theory by which they are established."

(495.) Reception of Fresnel's theory; The memoir on double refraction was received with much incredulity and partial applause. It was not to be supposed that a theory in opposition to that imagined by Newton, and received with almost general assent for more than a century and a half, would not meet with many opponents; but in the case of double refraction and polarization it was also essentially coupled with the idea of transverse vibrations, whose exact mechanism was admitted on all hands to be extremely obscure. Laplace, now more than seventy years of age, opposed the new opinion in France, to the last. His reason for doing so was eminently characteristic of the great geometer—"it was one to which analysis could not be applied without much difficulty;" to which Fresnel replied, "that it was still harder to believe that the laws of nature were arrested by such obstacles." Poisson, as might have been expected, was equally opposed to the undulatory doctrine, for he was still less of a physicist than Laplace. His standing argument against it was its inability to explain dispersion. M. Biot, also a keen supporter of Laplace, was still more strongly compromised to the theory of emission. The inertia of such authorities at the Institute retarded of course the growth of Fresnel's reputation at home, notwithstanding the great weight of his friend Arago's opinion. in England. It was in fact in England that the merits of Fresnel were first most generally and liberally acknowledged; as, singularly enough, Young had received almost the first expression of sympathy in his optical discoveries from France. In 1825 Fresnel received the distinguished honour of being elected a foreign member of the Royal Society of London, only two years subsequent to his election into the Institute, and whilst his greatest paper was as yet known only by an abstract. In 1827 he received the Rumford medal from the same body. This recognition of his merits was due, as we learn on the authority of Dr Young (who was then Foreign Secretary of the Royal Society) to the influence of Sir John Herschel, at that time and afterwards a zealous supporter of the undulatory theory of light, and by whom it became first generally known in England through the medium of his admirable *Essay on Light.* Dr Young, though present, was silent; "from being," as he himself tells us, "too much interested in the subject" on account of his personal share in the matter. In announcing this distinction officially to Fresnel (then in the last stage of consumption), Young characteristically observed, "I too should claim some right to participate in the compliment which is tacitly paid to myself in common with you by this adjudication; but considering that more than a quarter of a century is past since my principal experiments were made, I can only feel it a sort of anticipation of *posthumous* fame which I have never particularly coveted."[2]

(496.) Fresnel's system of lighthouse illumination. I have stated in the opening of the section that Fresnel, who was attached to the Bourbon cause, had retired to Normandy near the close of Napoleon's career. On the re-establishment of the monarchy in 1815 he was recalled from his retreat and appointed to an office in the departments connected with his profession as an engineer; but in 1817 he was brought to Paris with the express view of giving him more facility in his researches. In 1819 he was placed on the Commission for the Management of the Lighthouses of France (of which he afterwards became Secretary), and he entered with ardour on the application of his favourite science of optics to the duties of his profession and the benefit of mankind.

(497.) The use of lenses in place of reflectors for preventing the indefinite dispersion of the light employed, and the effectual concentration of it in the direction where it will be most useful, was not altogether new. The construction of immense lenses of glass of no great thickness, formed by grinding out a series of concentric refracting surfaces having a common focus, had also been proposed by Buffon, and the idea of constructing these rings or *échélons* separately and then uniting them had been suggested by Condorcet in his *éloge* of Buffon, as well as at a later period by Sir D. Brewster. These proposals were all alike unknown to Fresnel, who had the grand merit, in a case of this kind, first, of carrying his happy idea into effectual execution, and secondly, of giving it a wonderful extension by the invention of a multitude of other forms of refracting and totally reflecting apparatus, till then unimagined as well as unexecuted.[1] In 1823 the lighthouse of Corduan, at the mouth of the Garonne, was furnished with the new lenticular system, which was very skilfully executed by Soleil of Paris. The illumination was provided by means of a beautiful and powerful lamp with several concentric wicks, the joint invention of Fresnel and Arago, which gave twenty-five times the light of the best Argand then in use. The system was found to work so well that it was speedily extended in France, then to Holland, and in the third place to Scotland, principally through the energy of the late Robert Stevenson and the present Mr Alan Stevenson, his son, to the latter of whom we owe the best and most compendious treatise on the subject of lighthouses,[2] as well as the noblest exemplification of it in the Skerryvore Lighthouse, erected by him in 1843. The same small work contains the details of Fresnel's admirably ingenious applications of the principle of refraction to the distribution of light under almost every circumstance, which were not, however, published by their inventor.

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[2] Peacock's *Life of Young*, p. 401.

(498.) His premature death. In 1824, consequent upon his exertions as examiner at the Polytechnic School, Fresnel had the first seizure of the malady which brought him to the grave at the premature age of 39, on the 14th July 1827. Eight days previously to his death he had received at the hands of Arago the Rumford medal before referred to, which his distinguished friend Malus had obtained under like melancholy circumstances 16 years before.

(499.) Character of Fresnel. From what has been stated it will appear that Fresnel eminently possessed the qualities requisite for original investigation. So finely balanced a combination of mathematical skill and attainment with profound inductive sagacity has rarely been witnessed. Had Young not happened to precede him there can be no question but that he would have made the undulatory theory entirely his own. Fresnel was superior to Young in the talent for devising and executing critical experiments, in which indeed he showed a degree of skill equally rare and admirable. It is hoped that his surviving brother, M. Léonor Fresnel, who is well qualified for the task, will collect his scattered papers and edit them, with a suitable biography. The *éloge* of Fresnel, written by the man most competent to render him justice—Arago—remained more than twenty years among the unedited papers of that philosopher, and has only appeared since his death in 1853. The cause of this suppression was one of those partly political and partly personal disputes which seem almost inseparable from the proceedings of the Institute. The *éloge* was announced to be read just two days before the Revolution of 1830 burst forth; Arago could not persuade himself at such a moment to discuss the merits of the Theory of Double Refraction without committing himself also on the politics of the day. Disputes arose, friendships cooled, and the unlucky work was returned to the author's desk. Hence no biography of Fresnel appears in the publications of the Institute, but his reputation will be treasured in France and elsewhere, when the more conspicuous laurels of many of his compeers are withered and half-forgotten.

§ 4. ARAGO.[3]—*Short Account of his Scientific Career—He discovers the Colours of Polarized Light—Laws and Theory of Depolarization;* M. Biot; Young; Fresnel.—*Non-interference of oppositely Polarized Rays—Rotatory Action of Quartz.*—M. Foucault's *Experiment on the Velocity of Light.*

(500.) Arago:— DOMINIQUE FRANÇOIS JEAN ARAGO, one of the most generally known of the philosophers of the half century just elapsed, though the author of a large number of miscellaneous writings which since his death have been edited in a collected form, has not left an amount of positive contribution to any one of the sciences at all in proportion to the reputation for ability which he very justly enjoyed.

(501.) his early life; He was born at Estagel near Perpignan, on the 26th February 1786, and the ardent temperament of a native of the south was one of his chief characteristics. From a fragment of his early history which he left behind him, it appears that he educated himself almost without assistance, and that when he was admitted to the Polytechnic School in 1803 (consequently at the age of 17), he was *intimately* acquainted with the chief writings of Lagrange, had studied the *Mécanique Céleste*, and had consequently in his possession far more mathematical knowledge than would have been required of him on leaving that celebrated institution. From the Polytechnic School he passed into the position of Secretary to the Paris Observatory. He pursued with M. Biot experiments on the refraction of the gases, and in 1806 the two young philosophers were despatched to the south of France and to Spain to continue the triangulation interrupted by the death of Méchain.[1]

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[1] One of Fresnel's lenses was used in 1821 for the geodetic operations connecting France and England, and the light was observed at a distance of fifteen marine leagues one hour after sunset.

[2] *Rudimentary Treatise on Lighthouses*, by Alan Stevenson. Weale, 1850. See also the *Account of the Skerryvore Lighthouse*, with numerous plates, in 4to, 1848.

[3] I may perhaps be thought to give Arago too prominent a place in the history of Optics. If so, it has arisen in part from

Geodetical observations;

The next three years were spent by Arago in a series of voluntary and involuntary journeys, perils by land and sea, from robbers, and from the Spanish government and populace, such as have been rarely equalled,—perhaps never in the pursuit of science. The declaration of war against France rendered his stay either in Valentia or in the Balearic Isles impossible, and he was conveyed in disguise from Majorca to Algiers, whence he twice essayed to reach Marseilles, but was once driven back to Africa by a storm, once made prisoner by a Spanish corsair. After great suffering, he at length reached France in July 1809, carrying with him the precious record of his geodetical operations. From this time his promotion was assured, and his life became tranquil and inactive, although the deep attachment which he formed with Baron Humboldt immediately on his return to France would probably have induced him to accompany that enterprising traveller to Central Asia, had that journey ever been accomplished. At the early age of 23 Arago attained the position of Member of the Institute, and was again attached to the Paris Observatory, of which at a later period he became director. He took a very active share in the proceedings of the Academy of Sciences, and became one of its secretaries in 1830.

(502.) Arago's subsequent career;

From the period of his election to the Institute, Arago's career was destitute of stirring incidents, but was, from first to last, devoted chiefly to science. It is certain, however, that he was deficient in that power of continuous application, to which alone great discoveries are commonly due. Full of ingenious, original, and even profound conceptions, he shunned the labour of realizing them. His appointment to the charge of the Observatory of Paris was perhaps unfortunate. Well versed in the theory of astronomy, the minute drudgery of observation and the control of numerous assistants, was altogether uncongenial to him. It was a duty imperfectly fulfilled, to say the least, for 40 years: and it is needless to add how much the consciousness of habitual neglect of a duty deadens the faculty of useful application to anything else.

(503.) If the science of astronomy then owes little to Arago, beyond the part which he took in geodetical observation, what are we to consider his chief claims to a place in this history? I have no hesitation in saying that they are to be found in connection with the discoveries and labours of his attached friends, Malus and Fresnel, and therefore we group them together in this chapter. Arago not only himself made some important optical discoveries in 1811 and the following years, but he was instrumental, as we have seen, in a very important degree, in calling forth the genius of Fresnel, and in obtaining a public recognition of the labours of Young; a service not the less worthy of note because of its eminently disinterested character. The undulatory theory of light, one of the greatest triumphs, if not the greatest, of our age, stands where it does in no slight degree through the instrumentality of Arago.

His optical labours of most importance.

One of his most considerable discoveries was that of the colours which crystallized bodies develop in white light polarized before incidence on the crystal, and afterwards transmitted through a rhomb of calcspar. These colours, by their order, the singular manner of their occurrence and disappearance, and in certain cases by their extraordinary and beautiful forms, offered a problem at once the most attractive, the most definitely marked, and the most seemingly inexplicable which had been met with in optics for much more than a century. They exemplified a new mode of analyzing light, evidently connected with the molecular forces concerned in crystallization; and for their display it was necessary that light should be in that peculiar and yet mysterious state called *polarized*. (504.)

Colours of crystallized bodies in polarized light.

The substances he employed were principally selenite, rock-crystal, and mica. When plates of the first and last of these minerals, formed by their natural cleavage, are placed in a beam of polarized light, and the light transmitted by them is then *analyzed*, by being passed through a doubly-refracting prism or thrown on a screen after reflection at the critical angle from glass, splendid colours are the result. These colours vary with the thickness of the plate, with its inclination to the incident light, and, what is most remarkable, they vary in intensity by merely turning the plate of selenite round in its own plane. When only this last motion is made, there are two positions of the plate where no colour results, the light passing through unchanged; and these positions are at right angles to one another. At all intermediate angles colours appear, the light is said to be *depolarized*, and this depolarization is most complete when the plate is moved 45° from (505.)

Phenomena of depolarization.

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the difficulties inseparable from the biographical system which I have adopted. My intention was to have thrown together the labours of Malus, Fresnel, and Arago into one section. But having written the different portions separately, there seemed so much precision and facility of explanation to be derived from treating of them consecutively, that I sacrificed, in some degree, the biographical principle to that of systematic classification; placing under the name of *Malus* what referred to the empirical laws of double refraction; under that of *Fresnel* the doctrine of transverse vibration (though mainly due to Young); and under *Arago* the discoveries of Young, Fresnel, Biot, and others, relative to the great subject of chromatic polarization, to which he gave the first impulse. The establishment of the undulatory theory, principally due to Young, Fresnel, and Arago, I have considered as deserving of a more detailed and systematic treatment than almost any other of the numerous discoveries of which I have to speak in this Dissertation. I may add, that the biography of Arago not appearing in its alphabetical place in the *Encyclopædia*, M. Arago being still alive at the date of the publication of that part of the work, it has been incumbent upon me to enter into more details than I should otherwise have done.

[1] See Chapter III., Art. (166) of this Dissertation.

the positions in which the light passed through unchanged.

(506.) Observation of Malus, Arago, Sir D. Brewster, and M. Biot,

The theory of this simple yet admirable experiment is one of the happiest examples of Fresnel's mechanical explanation of double refraction. But it was not attained by a single step, nor effected by a single hand. Malus had observed the fact of depolarization, and the existence of perpendicular neutral axes in the crystalline plate. Arago added to this the knowledge of the phenomena of colour, which Sir David Brewster also observed independently somewhat later. He also invented a particular theory to explain them by what he termed *moveable polarization.* But it was not a successful effort. M. Biot assiduously studied the empirical laws of these periodic colours, and traced their dependence on the thickness of the interposed plate, according to a law similar to that of Newton's rings. Young made an important step farther. He attributed the colour to the *interference* of the ordinary and extraordinary rays into which the incident light was divided on entering the crystalline plate; and he showed by accurate calculation that the retardation of the slower-moving of the two rays during their passage through the plate, did in fact produce the difference of phase necessary for developing the tints observed by their reunion on leaving the plate, according to the usual laws of interference; and he showed that this theory coincided with M. Biot's rules.[1] But even this was not enough to explain the facts. It was not clear why the colours due to doubly-refracting plates should not be seen without reaching the eye through an *analyzer*, or calc-spar prism. To Arago and Fresnel jointly we owe the important reply to this difficulty, which in fact forced upon the latter the idea of transversal vibrations. Their joint experiments (mentioned in the last section, art. 488), had shown that oppositely polarized rays cannot interfere unless they have, first, a common origin and a common plane of polarization; and, secondly, unless they be reduced to a common plane of polarization (that is, *analyzed*) before falling on the eye or the screen: so that the theory of the colours of crystallized plates is, briefly, as follows:—

attributed to interference by Young.

Case of rays oppositely polarized—Arago and Fresnel.

(507.) Depolarization explained on the undulatory theory.

Polarized light is represented by transverse vibrations of ether, the particles moving all in one plane. The crystallized plate has, we will suppose (in order to take the simplest case) one axis of double refraction, and the direction of that axis is in the plane of the lamina. When the vibrations of the light falling on the crystallized plate are either wholly parallel or wholly perpendicular to this axis, the light is transmitted without alteration, either as an extraordinary or as an ordinary ray, and it is then reflected or not by the analyzer, as would have been the case had it not been transmitted at all through the crystal of selenite. But if the axis of the crystal be inclined, suppose 45°, to the plane of vibration of the incident polarized ray, the vibration is mechanically resolved into two, which are oppositely polarized. After traversing the thickness of the crystallized plate with the different velocities due to the motion of the ordinary and extraordinary rays, they are reunited at emergence, *but in altered relative phases*, so that by their union they form a beam no longer polarized (unless by an exception) in the same plane as at first, nor indeed plane-polarized at all, but most likely performing elliptical or circular vibrations, which, again, falling on the analyzer, are reflected or transmitted, or partly both, in a manner quite different from what would have happened to the light unchanged by crystalline transmission.

(508.) Cause of the colour.

White light becomes coloured because the state of polarization of the emergent ray depends on the difference of length of path for the two rays which underwent crystalline separation within the plate, and also on the length of a wave of light (for this determines the phase of polarization at emergence). But the wave of light varies in length for each colour, consequently every colour has its maximum under different circumstances, and if the incident light be white, the light falling after reflection on a screen will present mixed tints similar to those of Newton's rings.

(509.) Similar phenomenon in radiant heat.

This extraordinary property of a crystallized plate (which, in common light, appears equally transparent and homogeneous in every direction), of modifying light, or dyeing it with the most gorgeous colours, when the plate is merely turned in its own plane, is one of the nicest tests of the polarization of the light, and has been used to detect the analogous polarization of radiant heat, and the concomitant phenomenon of double refraction, which, except in the case of the heat accompanying the solar rays, has not yet been independently recognized.[2]

(510.) Arago's polariscope.

Arago applied his discovery to the construction of a *polariscope*, for estimating the feeblest amount of polarization; and he used this instrument for some very interesting experiments on the polarization of the light of the sky (which is sunlight polarized by reflection from the atmosphere), and on that of different incandescent and reflecting surfaces. He also found that the moon and the tails of comets send light to the eye which is slightly polarized, thus betraying its borrowed origin. But that of the sun, being absolutely neutral, is only comparable (according to Arago) to the light arising from incandescent vapours, thus distinguishing the sun from a solid or liquid globe.

(511.) Experiments on Newton's rings and

We cannot do more than allude to Arago's other optical papers and experiments. He was, probably, the only Frenchman of his time who was well acquainted with Young's discoveries. The explanaon the rotatory action of quartz.

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[1] *Quarterly Review*, vol. xi.; *Miscell. Works*, vol. i., p. 266.

[2] See Researches on Heat by the present writer. *Edinburgh Transactions*, vols. xiii. and xiv.

tion by the doctrine of interference of the colours of Newton's rings received an important confirmation from an experiment of Arago's, which proved them to arise from the mixture of the pencils of light reflected at the two neighbouring surfaces. He pressed a lens of glass against a plate of metal, in which case the central spot is white or black when light polarized perpendicularly to the plane of incidence is reflected at an angle greater or less than the polarizing angle for glass; and the rings vanish altogether at the polarizing angle;—results which have been found conformable to the undulatory theory.[1] He also discovered the peculiarity of the rays transmitted along the axis of a crystal of quartz. These depolarize light, or produce colours similar to those of crystallized plates, varying according to a well-marked law with the thickness of the plate. The most singular fact is, that by turning round the analyzing plate, no position of neutrality is found, but a series of colours similar to those of Newton's scale succeed one another. Arago showed that this effect is due to a rotatory motion of the plane of polarization within the crystal. The rotation is greater for the violet than the red ray; this was shown by M. Biot, who also discovered that in some specimens the rotation takes place from right to left, in others from left to right—a peculiarity connected with certain crystallographic modifications, as was first shown by Sir John Herschel.

(512.) Rotation of the plane of polarization in fluids.

MM. Seebeck and Biot discovered an analogous property in oil of turpentine, and in various saccharine fluids, an observation which, in many cases, allows the substitution of an instantaneous optical, for an operose chemical test. Fresnel has shown that the phenomena of quartz may be represented on the supposition that the rays traversing the axis consist of two rays circularly polarized in opposite directions, and travelling with different velocities; and Mr Airy succeeded in calculating, by the aid of this fundamental hypothesis,[2] a number of most beautiful and complicated phenomena, such, for example, as those which occur when plates of right and left handed quartz are superposed. Maccullagh has shown how the generation of elliptical or circular vibrations may be deduced from the general equations of motion, but he has not invented a mechanical theory to explain them. This is a point of the very highest interest, inasmuch as Dr Faraday has succeeded, for the first time, in inducing *artificially* in a substance the power of rotating the plane of polarization by the presentation of it to the poles of a most powerful magnet.[3]

(513.) Retardation of light in dense media proved by Arago.

Arago's experiments on the non-interference of rays of light oppositely polarized, being undertaken in conjunction with Fresnel, have been already referred to, arts. 488 and 506; but to Arago alone is due the ingenious idea of interposing a thin slip of mica or blown glass in the path of one of the interfering pencils, and observing the displacement of the interference-bands, which is always *towards* the side of the interposed slip, showing that the movement of the wave has been slower within the denser medium.

(514.) Experiment to the same effect by M. Foucault.

Arago continued to attach great importance to the obtaining of a still more direct proof of this fact, which he considered as a *crucial* one between the rival hypotheses of Newton and Huygens. In his last years he had the satisfaction of witnessing the accomplishment of it, with the result he anticipated, and by a method which he had himself indicated. In 1838, he had already indicated the application of Mr Wheatstone's beautiful invention of the revolving mirror,[4] as a means of measuring intervals of time incredibly short, in order to compare the velocity of light in air, and in a corresponding length of water. He even caused an apparatus to be partly prepared, but we have seen that Arago's *forte* was rather in suggesting than in completing researches. After his increasing failure of sight rendered it physically impossible that he should ever realize his own idea, it was skilfully adopted by M. Foucault (the author of the admirable experiment with the pendulum, demonstrating the earth's motion[5]), who, by an ingenious combination of fixed and revolving mirrors, succeeded in 1850 in demonstrating the retardation of light in a tube of water only $6\frac{1}{2}$ feet long, and with a velocity of rotation of the moveable mirror not exceeding 200 turns in a second (a rapidity four times less than had already been obtained by Mr Wheatstone). The rotation was produced by means of the Sirène of M. Cagniard de la Tour, acting by steam. The velocity was thus raised to 1000 revolutions. It was afterwards, however, carried by MM. Fizeau and Breguet to 2000 revolutions. It will be understood, from the account of the method, as applied to the measurement of the velocity of electricity, in another chapter, that the retardation is shown by the displacement of the image of a minute object seen through the water, relatively to the image of the same object seen in air. If light moves faster in water (as Newton imagined), the displacement of the water-image will be (let us say) to the right; but if slower (as Huygens and Young believed), it will be to the left. The calculated displacement, with 800 revolutions in a second, was ·004 inch on the first supposition, and ·003 in the opposite direction in the second, quantities easily visible with a high magnifying power. The result, as has been stated, confirmed Arago's original experiment of 1815 on the displacement of the interference fringes.

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[1] Sir W. Herschel first formed Newton's rings between glass and metal. Arago's experiment was reproduced (unknowingly) by Mr Airy in 1831, who first explained it fully in the undulatory sense. *Camb. Trans.*, vol. iii.

[2] With this addition, that rays inclined to the axis are *elliptically* polarized, and *that* with a greater ellipticity as the inclination increases.

[3] See the chapter on Electricity, § 5.

[4] See Electricity, § 6.

[5] See the chapter on Astronomy, Art. (258).

(515.) Arago's electro-magnetic observations. To complete our biographical notice, we will here just allude to M. Arago's principal researches unconnected with optics. One was on the magnetization of iron filings, and the formation of a temporary magnet, by means of a helical conductor of electricity;[1] the other was the important observation of the *seeming* magnetism of copper, and other non-magnetic metals, when put in rapid rotation near a permanent magnet. Neither of these happy experiments was carried out by their author. The former was left in the hands of Ampère, Sturgeon, and Henry; the latter was only rightly understood and valued when it was engrafted by Mr Faraday on his splendid series of researches on Magneto-Electric Induction.[2]

(516.) Essays on meteorology. Arago is fairly entitled to be regarded as having *proved* the long-suspected connection between the aurora borealis and the freely suspended magnet; and this in the face of urgent contestation. His contributions to Meteorology (founded rather upon the observations of others than upon his own) were of considerable importance, and several of his popular papers, appended to the smaller Almanac (*Annuaire*) of the Board of Longitude, contain a great deal of well-digested and curious information.

(517.) Arago as secretary of the Academy of Sciences. As Secretary of the Academy of Sciences in the Mathematical Department (in which office he succeeded Fourier, in 1830), the duty devolved on him of writing the biographies of eminent deceased members of the Academy. He bestowed extraordinary pains on these compositions, and strove to render them popular without sacrificing their scientific character. In this difficult attempt he was not always successful. Abrupt transitions, piquant anecdotes, paradoxical arguments, and political allusions, appear, at least to the English reader, to be unacademical adjuncts to the history of contemporary discovery. The special pleader is too often visible, and even the occasional sacrifices of the strong spirit of nationality by which he was commonly actuated, to some chivalrous adjustment of the rights of discovery, do not always carry conviction to the mind of the reader. The *Eloge* of Watt, probably the most popular, appears to us far from being the best of these biographies. Those of Sir W. Herschel and of Dr Young are ably executed, and display much research and candour.

(518.) His death. After having been for three years almost withdrawn from science by lingering disease, and nearly complete blindness, Arago expired at the Observatory of Paris, on the 2d October 1853, aged 67.[3]

§ 5. Sir David Brewster—*Progress of Experimental Optics—Laws of Polarization—Double Refraction produced by Heat and Compression—Discovery of Biaxal Crystals—Laws of Metallic Reflection—Absorption of Light; and Lines of the Solar Spectrum;* Fraunhofer.—Seebeck; M. Biot.

(519.) Sir David Brewster. We have pleasure in ranking amongst the foremost promoters of the science of optics in its surprising revival in the earlier part of this century, a philosopher who still lives amongst us and pursues with ardour the investigations of his youth.

(520.) His early studies. Sir David Brewster was born at Jedburgh, in Scotland, on the 11th December 1784. He was educated for the Scottish Church, and having entered the University of Edinburgh at a very early age, pursued his studies under Robison, Playfair, and Stewart, and formed the friendship of those eminent men. Amongst fellow-students of no common distinction who at that time frequented the college lectures, and of whom not a few were destined to signalize themselves in literature, science, and the career of politics, he formed the particular acquaintance of Mr, now Lord Brougham, and through him was led to study the inflection of light, and to repeat Newton's experiments. This was in 1799; nor did he afterwards lose sight of a science which he was so signally to improve. The distraction of other occupations, the calls of his profession, and his indifferent health prevented, however, any very constant application to optics: and the part of the subject he then principally studied was rather connected with the use and theory of instruments than with *physical optics* in the sense in which we have explained it. This is evident from his first separate publication in 1813, "on new Philosophical Instruments," which, though containing many ingenious and valuable suggestions, fell short of the importance of his subsequent publications.

(521.) Directs his attention to physical optics. Sir David Brewster's genius was first called forth by the announcement of Malus's great discovery in 1808 of the polarization of light by reflection. But for the unfortunate political relations of France and England at the time, which prevented, to a degree which now appears almost incredible, the transmission of even the most interesting scientific facts from one country to the other, our countrymen would have borne a larger share in the discoveries which immediately followed; and it would have been an easier task to apportion with historical accuracy what was due to each. As the French philosophers remained long in ignorance of the discoveries of Davy, and were anticipated in every important step in voltaic science, so Malus and Arago pursued and published researches and brilliant discoveries which, literally for years, remained unknown in England to those most interested and solicitous to learn them. Thus Sir D. Brewster learned first in February 1814 that Malus had in March 1811 published the discovery of the polarization of light *by refraction*, which he also had made; whilst Arago's experiments on coloured polarization were likewise unknown to him through the same want of international communication.

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[1] See Electricity, § 4.

[2] Electricity, § 5.

[3] The article Polarization of Light in this *Encyclopædia*, the production of Arago, contains an excellent review of many of the topics of this Section.

(522.) Treatise on new philosophical instruments. The work on Philosophical Instruments, mentioned above, contains, besides what its name more particularly imports, numerous observations on refractive and dispersive powers, including the discovery of substances more refractive than diamond, and less so than water. It also describes the property of some agates to transmit light polarized in only one plane. The imperfect polarization of light by metals and by a serene sky had been anticipated by Malus and Arago.

(523.) His researches on optical subjects. From this time (1813) Sir David Brewster became a regular contributor to the London Philosophical Transactions, which, as well as those of Edinburgh, contain a series of elaborate experimental investigations due to him, which have hardly been surpassed. It is difficult to overrate the importance of these researches, whether for the intrinsic interest of the phenomena they reveal, or for the significance of the empirical laws by which their author, with a rare sagacity, succeeded in classifying facts, and afforded a sure basis for farther generalization. The number and variety of these researches is so exceedingly great, and in many cases so impossible to explain without entering into minute detail, that I shall, in accordance with the plan of this essay, merely indicate some of the most generally important by arranging them in groups. Such are—

(524.) Enumeration of the most important. I. The laws of polarization by reflection and refraction, and other quantitative laws of phenomena.

II. The discovery of the polarizing structure induced by heat and pressure.

III. The discovery of crystals with two axes of double refraction, and many of the laws of their phenomena, including the connection of optical structure and crystalline forms.

IV. The laws of metallic reflection.

V. Experiments on the absorption of light.

(525.) Law of polarization by reflection. I. Malus had failed to discover a connection between the angle at which light is completely polarized by reflection, and the other known optical properties of bodies. In 1814, Sir D. Brewster discovered the beautiful and simple law, "that the index of refraction is equal to the tangent of the angle of polarization." He had suspected it much sooner, but he had been baffled by the irregular results obtained by reflection from glass, whose surface he found to undergo an almost imperceptible chemical change. He further observed that it is only in bodies of low refractive power that the polarization is sensibly complete, a result of great importance, which has been too much overlooked until the recent and valuable paper of Jamin on the same subject. He deduced as a corollary, that at the maximum polarizing angle the incident and refracted rays are at right angles to one another, and also Malus's experimental result that the rays reflected from the first and second surfaces of plates are *simultaneously* polarized. He further discovered the fact that light may be completely polarized (as to sense) by a sufficient number of reflections at any angle, and drew the conclusion that the *whole* light undergoes *some* change at each reflection, in opposition to the view of Malus, who maintained that, except at the polarizing angle, a portion of the light is polarized, and the rest is unchanged.

(526.) Imperfect polarization. Sir David Brewster independently observed the polarization of light transmitted obliquely through glass, and he calculated the number of plates necessary to polarize it with sensible completeness. All these researches he resumed some years after (*Phil. Trans.* 1830), endeavouring to give a photometric estimate of the effects of reflection and refraction under all circumstances. The results as regards partially polarized light may still be considered as subject to doubt. His skill in obtaining a mathematical representation of the phenomena was again displayed in a number of laws connecting the experimental results.[1]

(527.) Polarizing structure in heated glass; II. Malus had observed that a vast number of substances depolarized light more or less completely; and Arago found feeble traces of chromatic polarization in some specimens of glass. But the more definite characters of the beautiful phenomena of glass not perfectly annealed (which proved to be of unexpected importance) were noticed, independently, by Sir D. Brewster and Dr Seebeck of Nurnberg. The latter had priority in publication,[2] but the former correctly referred them to their immediate cause—the constraint produced by rapid cooling. Sir D. Brewster noticed that the unannealed glass which forms what are called Prince Rupert's Drops, had a remarkable power of depolarization; and he also observed subsequently that the plates of glass between which he was in the habit of squeezing heated wax and resins, for the purpose of optical examination, transiently communicated tints to polarized light. These observations, duly developed, proved on the one hand that glass (and generally refracting solids not usually possessed of any polarizing action) acquired such properties by being suddenly and unequally cooled; and on the other, that such substances undergoing partial changes of temperature, possess the same property. These phenomena are exceedingly beautiful, and easily displayed. It is sufficient to place a rectangular piece of glass, somewhat thick, with one of its longer edges in contact with a hot iron, and placing it between a polarizing and analyzing plate, to incline the heated edge 45° to the plane of polarization. Bands of light and shade are seen to traverse the glass parallel to the same edge, and simultaneously appear also on the side farthest from the heated metal. They pass gradually into rich coloured tints diffused with geometric regularity. In the case of cubes or cylinders of glass, suddenly, and therefore unequally cooled, the phenomena are permanent, and the colours splendid, being arranged in patterns which may be made to resemble those of natural crystals.

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[1] Thus he found that the effect of refraction on the plane of polarization of the incident light may be expressed by this simple formula—$\cot a' = \cot a \cos(i-i')$, where a and a' are the azimuths of the planes of polarization of the incident and refracted rays measured from the plane of reflection, and i and i' the angles of incidence and refraction. This result, admirably verified by experiment, is also conformable to Fresnel's theory.

[2] In *Schweigger's Journal* for 1813, vol. vii. I have not been able to find in this paper (which contains the first account of the beautiful symmetric coloured figures displayed in cubes and cylinders of glass) the smallest trace of the true cause of the phenomenon, viz., the sudden or partial cooling of the glass.

(528.) and in bodies subjected to pressure.

Sir David Brewster at first ascribed these effects to the direct effect of the heat in the glass upon light, and compared its simultaneous influence over a whole plate to a polar influence. Another curious discovery, also due to him, leads to the simpler conclusion, that in every case the development of a polarizing structure is due to the varying tension (transient or permanent) into which the particles of the glass are thrown by local expansion or by irregular cooling. This discovery was, that similar effects may be produced in jellies and soft transparent substances by the effect of pressure, and that even glass itself, when strained in any way by mechanical force, shows depolarizing bands; and crystals may have their peculiar optical phenomena altered by pressure. Fresnel, not satisfied with inferring that the chromatic display is due to a doubly-refracting structure communicated to the glass, contrived, by an ingenious arrangement of prisms, actually to exhibit the separation of the images under the action of powerful pressure.

(529.) Discovery of biaxal crystals.

III. Possibly the most remarkable of Sir David Brewster's discoveries,—at all events, that which probably cost him most labour to develope,—was that there are crystals possessing two axes of double refraction, and showing many remarkable phenomena, which indicate a connection between optical structure and crystalline form. No one before him suspected the existence of a doubly-refracting structure differing from that so ably investigated by Huygens and Malus in Iceland spar. In 1813 Sir David Brewster had discovered coloured rings in topaz when viewed by polarized light. Though intimately connected with M. Arago's observation of colours in crystallized plates, these interesting phenomena had a still more extraordinary and geometrical character. When a plate of topaz, split by natural cleavage, was presented between the polarizing and analyzing plate (or rhomb of calc-spar), and at the same time inclined in a certain manner, the colours were no longer in broad sheets, but, if viewed closely, they arranged themselves in oval rings of great beauty, presenting *orders* of mixed colour analogous to those described by Newton when formed between convex glasses, and they were traversed by dark or white brushes as the analyzing plate was held in the dark or bright position. A second such system was observed inclined at an (apparent) angle of 65° in the same plate.

(530.) Phenomena of polarization shown by uniaxal crystals.

Dr Wollaston afterwards (1814) discovered a phenomenon equally beautiful in calcareous spar, of which Sir D. Brewster had already perceived traces in some other crystals. Concentric with the position of the axis of double refraction (or *optic axis*), in a crystal of that mineral cut with two parallel faces perpendicular thereto, a series of perfectly symmetric and exquisitely coloured rings are seen in polarized light, having a white or black *cross* traversing them, according to the position of the analyzing plate. This magnificent phenomenon, which (excepting, of course, the rings of biaxal crystals mentioned above) has perhaps no parallel in optical science, is seen in the most perfect manner possible in an apparatus constructed solely of Iceland spar, cemented by Canada balsam. A Nicol's single-image prism[1] is used to polarize, another to analyze the light, and between them is a plate of calcareous spar properly cut. It is a truly astonishing paradox to see the union of three perfectly transparent and colourless crystals display by their union such an exquisite combination of form and colour. The pole or centre of the rings in calc-spar coinciding with the axis of double refraction, of necessity suggested the idea that topaz, which shows *two* systems of rings arranged round two poles, must possess two axes of double refraction; in other words, that there must exist within the crystal two *directions* (not mere *lines*), parallel to which a transmitted ray emerges without subdivision into two pencils.

(531.) Double systems of topaz, nitre, &c.

This probable conjecture was verified by careful observation, not only in topaz, but also in a vast variety of other crystals which were found by Sir David Brewster much more commonly to possess two than one system of rings. Amongst the earliest examples which he observed were nitre, mica, acetate of lead, and Rochelle salt. Of these the first is exceedingly remarkable for the small inclination of the axes (about 5°) which permits both systems of rings to be readily observed at once. It was not, however, for some years (1817) that he reduced these most curious phenomena to anything like a law. It was evident almost from the first, that the axes in question (which he termed axes of no polarization) are only the *resultants* of remoter fundamental actions of the crystalline constitution. For example, these axes vary in position according to the colour of the light used to display them; their position within the crystal varies (as was shown by Mitscherlich) with the temperature of the body, nor is it obviously related to any of the geometrical lines of crystallization. Law of the tints. Sir David Brewster succeeded in finding the law of the tints expressed upon the surface of a sphere of which the directions of the two axes form diameters. M. Biot expressed the law more elegantly by saying, that the tint developed by a biaxal crystal in any ray, is proportional to the product of the sines of the angles which the ray in question makes with the two optic axes. The tints are consequently arranged round the two poles of the axes, in a series of curves resembling the figure 8, having each this property, that the product of the sines of the angular distances of each point of one curve from the two poles is equal to a constant quantity. Such curves are called lemniscates, and are beautifully seen in nitre, especially when viewed by homogeneous light.

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[1] The invention of a most ingenious person, the late Mr William Nicol of Edinburgh. One of the doubly-refracted rays is thrown completely out of the field by undergoing total reflection at the surface of a film of Canada balsam in contact with the spar, whilst the other less refrangible ray proceeds quite isolated, and with scarcely any loss of brilliancy. It is of almost universal application in this branch of Optics.

(532.) Relation of optical characters to crystalline forms. A series of researches of the most elaborate description led Sir David Brewster to this additional and admirable discovery, viz., that the optical characters of single refraction, double refraction with one axis, and double refraction with two axes, have reference invariably to the primitive crystalline form of the mineral, and that the complexity of the optical character is as invariably related in degree to the complexity of the crystalline figure. Cubical and *regularly* octahedral crystals (as *rock salt* and *fluor spar*) being possessed of perfect symmetry in three principal directions, possess also simple refraction. Crystals with one predominant line or axis of symmetry —as rhombohedrons, octahedrons with square bases, right prisms with square or hexagonal bases—have a single axis of double refraction. Such, for instance, are *Iceland spar*, *zircon*, *ice*, *beryl*. Finally, all crystals unsymmetrical in the three principal directions, including prisms and octahedrons whose bases are not *square*, and those which are oblique, have *two* axes of double refraction. The rarity and minuteness of many crystals, the difficulty of cutting them, and when cut, of detecting their optic axes, evidently made the research one of extreme labour, yet highly remunerative, not only through the discovery of the general principle, but by the vast amount of beautiful and varied optic displays witnessed in the course of it. Sir David Brewster was nearly, if not quite, alone in this research, and after a short resistance on the part of some mineralogists, his principle of discrimination of primitive forms of crystallization by optical characters has been perfectly established.

(533.) IV. The action of metals on the light which they reflect is very peculiar. Laws of metallic reflection. Malus, who at first believed that they were incapable of polarizing it in any degree, afterwards changed his opinion, and ingeniously suggested that whilst transparent bodies reflect, at the polarizing angle, light polarized only in one plane, metals reflect rays oppositely polarized and then mixed. Sir David Brewster has the merit of having, after several unsuccessful attempts, deduced the leading empirical laws of metallic polarization, having been partly guided (as he states in his paper in the *Philosophical Transactions* for 1830) by Fresnel's remarkable experiments on circular polarization produced by total reflection in glass (see Art. 491). Having found qualities somewhat analogous in light reflected one or several times from metallic plates at various angles depending on the nature of the substance, he gave to the light so reflected the name of elliptically polarized light. It was afterwards satisfactorily proved by Mr Airy that the light so named by Sir D. Brewster is in fact identical in its qualities with the elliptically polarized light of Fresnel.

(534.) Metallic polarization. The subject of metallic polarization is rather too abstruse to be explained in a popular way; and the phenomena produced with depolarizing plates of different metals are not so well known as, according to their discoverer, they deserve to be. My limits only permit me at present to state that the care and accuracy of Sir D. Brewster's results are unquestionable; that they have formed almost the sole data upon which M. Cauchy and other mathematicians have based their theories of metallic reflection; and that, by generalizing the more limited views entertained by Fresnel as to the constitution of media and the nature of reflected light, they have been mainly instrumental in fixing the later views of optical writers as to the precise phenomena of polarization as produced, not only by metals, but by other substances. To these views I shall briefly advert in the next section.

(535.) The laws of the reflection of light at crystallized surfaces have also been studied by Sir D. Brewster. In this case observation is still in advance of theory.

(536.) Absorption of light. V. Of Sir David Brewster's experiments on the absorption of light we must speak much more briefly. White light is coloured or analyzed by refraction (as in a prism); by simple interference, as in Newton's rings; by double refraction combined with polarization. But it is also decomposed in a way which, primarily at least, seems different from all these,—by passing through coloured, or rather, colouring media, whether solids, liquids, or gases, as red glass, ink, chlorine. This, the most familiar mode of coloration, is the most difficult to account for, and has been (on account of its obscurity) less studied than the others. In some instances, the complementary colour (that which, added to the transmitted tint, makes up white light) is entirely absorbed or lost; in other cases it is reflected at or near the first surface of the medium. Sometimes the transmitted light is made up of different portions of the spectrum curiously blended, whilst rays intermediate in the order of refrangibility are wholly stifled. Many crystals have the curious property of *dichroism*, that is, of transmitting light of different colours in different directions. All these facts have been very carefully studied by Sir David Brewster.

(537.) Singular action of nitrous acid gas on light.

But the most remarkable phenomenon to be noticed under this head is the wonderful action of nitrous acid gas upon light.[1] When a beam, either of sunlight, or the light of a lamp, is passed through a bottle containing a small quantity of fuming nitrous acid, the light emerges of a tawny orange colour, which may be deepened indefinitely by heating the acid. If this light be then analyzed by a common prism, a wonderful spectacle is seen. The spectrum appears traversed by countless bands or dark spaces, whilst the blue and violet colours are nearly absorbed. The effect of the gas, then, is this,—to stifle or absorb countless minute portions of light seemingly selected at random from every part of every colour in the whole spectrum. Some of these deficient rays are broad and palpable, but most of them are so fine as to be visible only with the telescope. To understand the full import of this discovery, it is necessary to describe first the *lines of Fraunhofer*.

(538.) Fraunhofer—Lines of the spectrum.

Joseph Fraunhofer, born in Bavaria, of humble parents, in 1787, raised himself by his unassisted efforts to be the first practical optician of the day. He had also the merit of devoting his leisure and the fine apparatus at his command to the observation and discovery of many optical phenomena, particularly those diffractive colours produced by fine gratings, which are known under the name of Fraunhofer's spectra.[2] His principal discovery, however, was (in 1814) that of countless deficient or dark lines in the *solar* spectrum, resembling those which, as we have mentioned, were afterwards observed by Sir D. Brewster, to be produced in any kind of light by the action of nitrous gas. The deficient rays of solar light had, indeed, been observed still earlier (in 1802) by Dr Wollaston, but he counted only a very few of the more conspicuous ones; he described them merely incidentally, and (unusually with him) seems not to have perceived the great value of the discovery both in a theoretical and practical point of view.

(539.) Their number and importance.

Fraunhofer's beautiful map of the spectrum, traversed by lines of every grade of darkness, and clustered with every conceivable variety of distribution, was published in the *Munich Transactions*. He counted 590 lines, but Sir D. Brewster states that he has carried the number to 2000. Like the stars, they are probably countless. These lines characterize *solar* light. The light of the fixed stars and that of the electric spark have their peculiar deficiencies different from those of our sun. These were discovered by Fraunhofer, as well as their occurrence in certain coloured flames. The order and number of the lines is, in each case, independent of the kind of prism used; but the *angular distribution* of the deficient rays varies with the material. Thus an oil of cassia prism expands most in proportion the less refrangible end of the spectrum; while water and sulphuric acid act with disproportionate dispersive energy on blue and violet light. This property of substances had been already studied by Sir D. Brewster with his usual diligence; but the importance of Fraunhofer's discovery was this, that the lines (the larger of which he distinguished by letters of the alphabet) furnish landmarks which define special rays of light invariably recognisable under all circumstances, which the vague description of their tints is quite incompetent to do. This enabled, on the one hand, the practical optician to discover the kinds of glass most fit for achromatic combination; and, on the other, it afforded precise numerical measures of the *quality of dispersiveness* in bodies which have been partly already, and will yet much more become, tests of some of the more obscure and difficult portions of the theory of light,—those, namely, which are connected with dispersion and absorption. Fraunhofer was, after Dollond, the most eminent and scientific manufacturer of achromatic telescopes, of which he vastly increased the aperture. He died at Munich in 1826.

(540.) Action of nitrous gas and of the earth's atmosphere on the spectrum.

Returning to Sir David Brewster's discovery of the *artificial* production of analogous lines or deficient rays in light from any source, its importance is easily perceived:—for, in the first place, it so far accounts for the strange phenomenon of the deficient rays of the sun's light, by showing that it may be caused by a gas resembling nitrous acid gas in its properties existing in the solar atmosphere; and, farther, if so astonishing a result of absorption is ever to be explained by theory, the first step is to be able to produce the phenomenon at pleasure, and to examine the qualities of the bodies producing it. The phenomena of coloured flames which possess standard deficient rays, present perhaps a closer analogy to the sidereal spectra. Sir David Brewster has farther found that the absorptive action of the earth's atmosphere (detected by the varying character of the spectrum for different angular altitudes of the sun) increases the number and also the breadth of these lines.

(541.) Sir David Brewster's analysis of the spectrum.

Intimately connected with, and nearly of the same date as these experiments, was an observation of Sir D. Brewster's, which has received less general assent than any other of the numerous and important ones which we owe to his genius. It is an analysis of the coloured light of the (so-called) homogeneous rays of the pure spectrum by the specific action of absorbing substances. Sir D. Brewster believes that he has separated the homogeneous orange of Newton into red and yellow, the green into yellow and blue; and that, in fact, each of the three primary colours exists at every point of the spectrum. But as grave doubts have been thrown on the results, especially by the recent careful experiments of Helmholz, I shall not further insist upon them here.[1] Still less can I take notice of a multitude of microscopic researches on a variety of objects in the animal, vegetable, and mineral kingdom, and on the physiology of vision, with which Sir D. Brewster has filled a multitude of memoirs, each bearing testimony to the zeal and acuteness by which his researches are directed.

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[1] *Edinburgh Transactions*, vol. xii. (1833).

[2] The peculiarity of these spectra is this, that they consist of *pure* colours, whilst almost all interference-colours are, like those of Newton's rings, mixed and impure. One result is very remarkable. Fraunhofer obtained his spectra of such brilliancy as to be able to measure the position of the dark lines (an evidence of their exceeding purity), thus obtaining a *standard spectrum* in which the material of the prism has no influence whatever in varying the ratio of the dispersion of the various colours.

(542.) His other scientific papers. Sir David Brewster received, in 1816, jointly with Seebeck, one of the great prizes of the Institute; he also received, in succession, all the medals in the gift of the Royal Societies of London and Edinburgh, and he is an honorary member of the principal academies of Europe. In particular, he is one of the eight associate-members of the French Academy of Sciences. To meteorology he has been a valuable contributor, having discussed in an able paper the law of the distribution of temperature over the globe, and pointed out the near coincidence of two regions or centres of greatest cold in the northern hemisphere, with the magnetic poles. His papers are so numerous, and their variety is so great, as to render an enumeration, even of those containing what may reasonably be termed *discoveries*, impossible within our limits. Few persons have made with their own eyes so vast a number of independent observations; few have ever observed better, or recorded their observations more faithfully. He has discovered (as we have partly seen) a multitude of laws of phenomena of the greatest importance in the construction of a theory, but he has not been forward in proposing such a theory. Neither the moveable polarization of Biot, nor the transverse undulations of Young and Fresnel, received his cordial assent. Generally speaking, he has been favourable to a corpuscular theory of light, without, however, attempting to render the Newtonian view mechanically consistent with the astonishing variety of complex phenomena which he aided in discovering, and which would evidently require it (to say the least) to be completely remodelled. His scientific glory is different in kind from that of Young and Fresnel; but the discoverer of the law of polarization, of biaxal crystals, of optical mineralogy, and of double refraction by compression, will always occupy a foremost rank in the intellectual history of the age.

(543.) Before closing this section I shall add a few words respecting the discoveries of MM. Seebeck and Biot, which have a very close relation to those of Sir David Brewster.

(544.) Seebeck. THOMAS SEEBECK was born in 1770. We have seen that he was one of the discoverers of the depolarizing structure of heated and compressed glass (527). In 1816 he observed, independently of M. Biot, the property of oil of turpentine and other fluids to rotate the plane of polarization of light transmitted through them, thus acting similarly to a crystal of quartz on a ray passing along its axis (512). Previously to these discoveries he had repeated Sir William Herschel's experiment on the position of maximum heat in the spectrum, and found it to vary with the material of the prism. When the science of electro-magnetism was created by Oersted in 1819, his attention became chiefly directed to that class of phenomena, and in 1823 he was fortunate enough to discover thermo-electricity. He also wrote many papers on allied subjects. He was a skilful observer, but deficient in the power of physical analysis. He died in 1831.

(545.) M. Biot—his numerous researches. M. BIOT, at the time I write, the oldest member (I believe) of the Academy of Sciences, and one of the veterans of European science, was born at Paris in 1774, and has lived to the age of 80, a life of almost unintermitted intellectual labour. It is impossible not to be touched by the evidence of such unconquerable love of knowledge. He was, if I mistake not, one of the original pupils of the Polytechnic School; and his talents being first developed in an almost purely mathematical direction, he attracted the notice of Laplace, who introduced him to the Institute, and by whom he was always befriended. In 1802 he published a work on curves and surfaces of the second degree, and was the first after Lambert who thought of applying mathematics to the theory of conducted heat. From this time his attention was almost exclusively directed to the applied sciences, and the number and variety of his experiments and writings almost baffles enumeration. Descriptive and practical astronomy, the theories of sound, of light, of the voltaic pile, of terrestrial magnetism, of electro-magnetism, of heat, radiant and combined, have been the subjects of his studies and writings. We find him in the earlier part of his career associated with Gay Lussac in his first aeronautic expedition, and with Arago in the geodetical and astronomical operations of the great arc of the meridian. He afterwards carried the pendulum to the Island of Unst, the northmost land in Shetland; and he made original experiments on the propagation of heat and of sound. He wrote a voluminous treatise on descriptive and practical astronomy, one still more elaborate on general physics, and a vast number of miscellaneous papers in the *Journal des Savans* and the *Biographie Universelle*. His original memoirs in the Transactions of the Academy are usually very long and elaborate, his calculations and empirical formulæ laboriously accurate. One of his papers fills an entire volume of the Academy's Memoirs. Even the astronomical hieroglyphics of the Egyptians, and the chronology of Chinese eclipses, have drawn from his pen learned treatises; and he has expounded the labours and discoveries of his countrymen and others with almost as much care and effort as if they had been proper to himself. But his subject by predilection was optics, and here he made his most considerable discovery, and that which he has followed out with most minute industry, namely, the rotatory action of fluids, in which he had Seebeck for a co-discoverer. (See Art. 512.) He studied the colours of crystallized plates with exemplary patience, and as we have seen in the preceding section, by his accurate observations on the law of the tints, prepared the way for the theory of transverse vibrations; but his own doctrine of moveable polarization, which he imagined to explain them, made no impression on the progress of science. He was the first who divided doubly-refracting crystals into positive (as quartz), and negative (as calcareous spar). In the former the extraordinary wave is a prolate spheroid, and inclosed within the ordinary spherical wave; in the latter the spheroid is oblate, and exterior to the sphere. He also discovered (very approximately) the law regulating the plane of polarization of the rays in biaxal crystals.

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[1] See Sir D. Brewster's statement and defence of his opinions in his Life of Newton, vol. i., p. 117, &c.

M. Biot has for about half a century been an active professor and member of the Institute. His researches, always marked by precision, are perhaps deficient in bold conjecture and happy generalization. They are conducted with a mathematical stiffness which allows little play to the fancy, and in hypothetical reasoning he rarely indulges. His style is formal yet diffuse, and consequently somewhat repulsive to the student. His works are consequently not easily read, and have contributed less to the progress of knowledge than the scrupulous care often evinced in their compilation might seem to warrant. Yet the name of Biot will be ever associated with devotion to science, and especially with the progress of optics in our own day. (546.)

§ 6. Mr AIRY, Sir WILLIAM R. HAMILTON, *and* Professors LLOYD *and* MACCULLAGH.—*Confirmation of Fresnel's Theory—Investigation of the Wave Surface completed; Conical Refraction.* —M. CAUCHY. *Mechanical Theory of Elastic Media, and of Ordinary and Metallic Reflection;* M. Jamin.—*Theory of Dispersion;* Professor Powell.

(547.) Progress of the undulatory theory since Fresnel.

It would not be possible, in one short section, to do justice to the various improvements and additions which the undulatory theory of light—the joint creation of Huygens, Young, and Fresnel—has received since the nearly simultaneous decease of the two last-named philosophers. But while a vast amount of labour and of mathematical and experimental skill has been thus expended, of which it would be in vain to attempt within our limits to give an account, we may pause upon two or three of the more conspicuous results of these researches, which, in conformity with the plan of this dissertation, may give a tolerable idea of their general tendency.

(548.) Peculiarities in its history.

Looking at the history generally, we find one curious peculiarity in the progress of this remarkable theory. Its origin in the seventeenth century was unattended with sympathy or success. It received little support, and was well nigh forgotten for more than an hundred years: it was then resumed (we might almost say re-invented) in England, but it remained unpopular and almost unknown until re-echoed from a foreign land; while in France itself the views of Fresnel were (with one or two exceptions) as little appreciated as those of Young had been in England. From this period England became the place of its chief development; and with the exception of one eminent philosopher, M. Cauchy, its supporters and extenders, whether by analysis or experiment, have belonged to Great Britain,[1] a few of the most conspicuous of whom are named at the head of this section.

(549.) Sir J. Herschel and Mr Airy.

The attention of the British public was forcibly called to the theory of Young and Fresnel, by an able treatise on *Light*, contributed by Sir John Herschel in 1827 to the *Encyclopædia Metropolitana.* The excellent method, lucid explanations, and intelligent zeal which marked this essay compelled the notice of men of science, too long deterred from the study of the fragmentary and abstruse writings of Young. It was followed four years later by a most able and precise mathematical exposition of the theory, and its application to optical problems, by Mr AIRY (now Astronomer Royal), who was then Plumian Professor at Cambridge, and who introduced this part of optics as a branch of study in that university. Whilst the excellent tract on the undulatory theory (published in 1831 in his *Mathematical Tracts*) opened up the subject in a most accessible form to British mathematicians, his original papers in the *Cambridge Transactions* confirmed the doctrines of Fresnel by a number of new and admirably contrived experiments, some in connection with interference, some with polarization, and all were confronted with the rigorous results of the mathematical theory. The paper on Quartz, and that on the Rainbow, have been already referred to (art. 466, 512). The writings of Mr Airy and of Sir John Herschel have continued to be the main sources of information on this subject, and on physical optics generally, not only in this country but on the Continent. It is remarkable that in France, which possesses so many admirable scientific books, there should not exist a single good treatise on optics. Had not Mr Airy's attention been necessarily withdrawn from optics to astronomy, it is very evident that the theory of light would have received from him many farther important additions.

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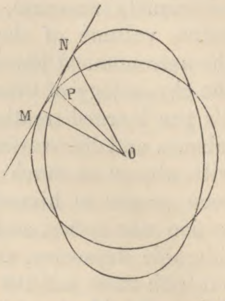
[1] M. Moigno (a Frenchman), writing in 1847, laments that France was then perhaps the only country in which the experiment of "conical refraction" (the triumph of Fresnel's theory to be presently mentioned) had never been repeated.

(550.) Sir Wm. R. Hamilton and Dr Lloyd.

Whilst an impulse was thus given to the mathematical theory of light in the University of Cambridge, a similar progress was being made in the sister University of Dublin, where three of her most eminent professors, Sir William Rowan Hamilton and Professors Lloyd and Macculagh devoted themselves energetically to its improvement and verification.

(551.) Conical refraction in biaxal crystals.

To the two former of these we owe the prediction and ocular demonstration of the most singular and critical of all the results of Fresnel's theory. Sir William Hamilton, a geometer of the first order, having undertaken the more complete discussion of the wave surface of Fresnel (see Section Third of this Chapter), to the equation of which he gave a more elegant form than heretofore,[1] ascertained the exact nature of that surface, and consequently the exact direction of refracted rays in the neighbourhood of the "optic axes." It had been shown by Fresnel that, in the case of crystals with *two* axes, a plane section in a certain direction cuts the two sheets of the wave surface in a circle and in an ellipse, which necessarily intersect each other in four places. (See the annexed figure.) In the lines joining these four points with the centre of the figure the velocity of the two rays is equal. Now the *cusps* or sharp inflections of the wave surface in these particular directions, occur not only in the particular plane of section which we have considered, but in *any* section of the wave surface passing through these lines of equal ray-velocity. In the figure, therefore, of the compound sheet there is not a *furrow*, as Fresnel had supposed, but a *pit* or dimple, with arched sides something like the flower of a convolvulus, and the surfaces meet at the bottom of the pit at a definite angle. Let the circle and ellipse, in the annexed figure, represent the section of the wave surface we have described; then O P is the line of uniform propagation, and P is the bottom of the conoidal pit M P N. Now suppose a slender ray of light to move through the crystal in the line O P, and to emerge into air at a surface of the crystal cut perpendicular or nearly so to the direction of single ray-velocity O P. If we confine our attention at first to the plane of the figure only, that ray having intersecting tangents both proper to the wave surface, would give rise, on Huygens' construction (art. 475), to *two* emergent rays inclined at an angle. But since this is the case, not only in the plane of the figure, but (as has been stated) in any plane passing through the ray in question, the emergent light must form a conical luminous sheet, the angle of the cone being determined by the refractive properties of the crystal. This beautiful and unexpected result was verified with great skill and address by Dr Lloyd in the case of Arragonite, which is a biaxal crystal, and he found the position, dimensions, and conditions of polarization of the emerging cone of light to be exactly such as theory assigns. When all the necessary corrections are attended to, the angle of the cone of light is about 3°. There is another case of conical (or it might be called cylindrical) refraction, which occurs nearly in the same portion of a crystal, which was predicted and discovered in like manner, but which we will not stop to particularize.[2] The observations of Dr Lloyd have been extended by M. Haidinger to the case of Diopside, a crystal also having two optic axes.



(552.) Other works of Sir W. Hamilton and Dr Lloyd.

Every one capable of appreciating such evidence, will feel the irresistible impression which so curious an anticipation, so accurately fulfilled, gives us of the positive truth of a theory admitting of such verifications. The names of Sir W. Hamilton and Dr Lloyd will be handed down to posterity in connection with this admirable discovery. But they have also other claims to our respect, to which we can here only refer in the most general terms. The former has generalized the most complicated cases of common geometrical optics by a peculiar analysis developed in his essays on "Systems of Rays" *(Irish Academy Transactions*, vols. xv.-xvii.)[3] To Dr Lloyd we are indebted for several interesting experimental papers on optics, for an able and impartial review of the progress of the science,[1] and for an excellent elementary treatise on the Wave Theory, which forms by far the best popular introduction to the subject.

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[1] The equation is— $\frac{a^2x^2}{x^2+y^2+z^2-a^2}+\frac{b^2y^2}{x^2+y^2+z^2-b^2}+\frac{c^2z^2}{x^2+y^2+z^2-c}=0.$

[2] It was shown by Sir W. Hamilton that the tangent plane M N touches the wave surface, not in two points merely, but in a *circle of contact*; consequently, the perpendicular to this tangent plane, OM, is the direction of one of the optic axes (or the velocity is the same for both portions of the compound *wave*). Hence a ray incident externally so as to be refracted along this perpendicular, will at entrance spread into a hollow cone interior to the crystal, and on emergence at a parallel face each portion of the ray recovers a direction parallel to its primitive direction, and a luminous hollow cylinder is the result. See Dr Lloyd, in the *Irish Academy Transactions*, vol. xvii., and Sir W. R. Hamilton's third supplement to his "Systems of Rays" in the same vol.

Quaternions.

[3] Sir W. R. Hamilton is also a discoverer in pure analysis and its connection with geometry. Following up the ideas of Mr Warren on the geometrical significance of the symbol $\sqrt{-1}$, as indicative of direction, Sir W. Hamilton has developed the theory of a new class of imaginary quantities, which he terms *quaternions*, by means of which he contrives to express simultaneously the direction in space and magnitude of a line or form; and this calculus he has applied to the solutions of problems of geometry and physical astronomy. The quaternion appears to express something even beyond this; and this redundancy has been considered as a difficulty by some mathematicians. The superfluous number is considered by Sir W. Hamilton as representing *time* in mechanical problems.

(553.) Maccullagh.

Closely associated in his pursuits, as in personal friendship, with Sir W. R. Hamilton and Dr Lloyd, was JAMES MACCULLAGH, a native of Tyrone, born in 1809, and who died prematurely and unhappily October 24, 1847.[2] His first paper was communicated to the Royal Irish Academy at the age of 21. It was one of the earliest original contributions of this country to the development of the theory of Fresnel. The construction of the wave surface in biaxal crystals was simplified and improved; and in 1835 a second paper appeared, in which geometrical constructions of great elegance were employed for the farther investigation of the subject. Mr Maccullagh next attacked the theory of the undulations of ether in quartz crystals, to which he gave a mathematical expression (see art. 512). In 1838 he published a paper on the laws of crystalline reflection, in which he adopted certain hypotheses, such as that the vibrations of the ethereal particles, in the case of polarized light, are *parallel* to the plane of polarization (contrary to Fresnel's opinion), and that the density of ether is the same in all media. In a subsequent memoir on the dynamical theory of reflection and refraction, he arrived at similar results with fewer physical assumptions, and by a more purely mathematical treatment of the subject. Subsequent researches, presently to be mentioned, have diminished the value of these theoretical investigations.

(554.) Mechanical theories of vibratory motion.

Numerous mathematicians of eminence at home and abroad entered upon the same arduous enquiry. To attempt to deduce from the hypothetical constitution of a very rare highly-elastic medium, together with the known dynamic laws, the various complicated facts of optics, was a problem whose difficulty was only equalled by its indefinite character. For how little do we know of the molecular constitution of such fluids as air and water? How much less then of a fluid (if we may so term it) almost infinitely rarer, and incapable of being inclosed, measured, or weighed? The bare possibility of *transversal* undulations was long contested by very able mathematicians; and conceding it, the mutual influence of such an ether and the particles of gross matter (as shown by reflection and refraction) must, it would seem, for ever remain problematical. Yet, however gratuitous or even erroneous our reasonings about such ultimate questions may be, there is no doubt a real benefit in obtaining from them at least a mathematical congruity with observed facts. The progress of science shows that there is a practical usefulness in this step. On the other hand, we must not be discouraged to find that there are so many handles to the matter, that even the most profound thinkers may conceive that they have reached the proposed end by different and incongruous routes. Besides the mathematicians whom I have mentioned, many others were in the field; for the result of tremors propagated through elastic media of different kinds is an enquiry of excessive generality, and forms a part of many branches of science besides optics. MM. Cauchy, Navier, Poisson, Coriolis, Green, Kelland, and Neumann are amongst those who attacked the problem. For a series of years memoirs rose fast and thick on this favourite battle-field; and even a skilful mathematician might find it no small penance to discuss the merits of the various hypotheses and the solidity of the respective deductions which were proposed.

(555.) Their bearing on optics.

It must be owned that a great part of this vast mathematical toil has been without immediate result in optics. It is by comparing the conclusions arrived at by authorities of seemingly equal weight, that we learn the difference between a stable physical induction and a clever mathematical hypothesis. Maccullagh, for instance, maintains the vibrations of ether to be *parallel* to the plane of polarization; Fresnel and M. Cauchy[3] that they are perpendicular. The first mathematician considered that the vibrations are wholly *transversal*, the last believes that the normal vibrations have also their share in affecting the phenomena, whilst Poisson denies that transversal vibrations can be propagated to a sensible distance. Maccullagh finds that, to account for metallic reflection, the indices of refraction of mercury and silver are 15·0 and 35·0, whilst Cauchy makes them but 1·77 and 0·34. One theorist assumes that the density of ether is the same in all bodies, another that it is greatest in a vacuum, and others precisely the reverse; one that vibration is not accompanied by change of density, another that it is;[4] and so on in almost endless variety. A matured opinion can only be formed after the results of the various assumptions, and their congruity with facts, have been more thoroughly worked out. Already two of Maccullagh's essential postulates have lost much of their plausibility; that respecting the direction of the vibrations in polarized light has been probably decided by Professor Stokes in favour of Fresnel's opposite view, by an admirably devised experiment on the effect of diffraction on polarized rays[1]; the existence of normal vibrations *seems* to be proved by the ingenious experiments of M. Jamin, showing that *at no angle* is light perfectly polarized by reflection. The more we see of these diversities arising in the progress of science, the less are we disposed to found on merely mathematical conclusions from an assumed constitution of elastic bodies; the more, on the other hand, do we admire the admirable sagacity of Fresnel—the real Newton of modern optics—few of even the least of whose suggestive anticipations have fallen to the ground.

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[1] *British Association Reports* for 1834.

[2] It is unnecessary to suppress the fact that Mr Maccullagh died by his own hand, under the pressure of a fit of despondency, brought on (it is believed) by over-work; a fate happily extremely rare amongst students of exact science. I say it is needless to suppress the fact, because it infers no blame. Mr Maccullagh was an amiable, pious, and exemplary man. Irresponsible insanity was, of course, the cause.

[3] This is M. Cauchy's last view; for some years he adopted the opposite one, which he then surrendered with great frankness.

[4] If, however, the vibrations were wholly transversal, it seems to be admitted that they would not affect the density of the medium.

(556.) M. Cauchy—his vast mathematical labours.

M. Augustin Louis Cauchy has been long known as one of the ablest and most prolific mathematical writers of this century. Besides numerous and important memoirs, on nearly every branch of pure and applied mathematics, published in the *Journal de l'Ecole Polytechnique*, and the Memoirs of the Institute, he has published, in a separate form, *Exercises des Mathematiques* in two series of volumes; and for many years scarcely a weekly meeting of the Academy of Sciences occurred without a mathematical memoir of this prolific author being laid on the table, and subsequently printed in the *Comptes Rendus.* The integral calculus and other parts of analysis form the subjects of a large part of these writings; but the theory of hydrodynamics in the earlier, and of optics in the later part of his career, are largely represented. So diffuse and desultory a mode of publication has been little favourable to those who wish to make themselves acquainted with what has been accomplished by M. Cauchy. The scientific world is indebted to Abbé Moigno[2] in France, M. Radicke[3] in Germany, and Professor Powell[4] in England, for analyzing in part his optical labours. As the present brief notice is evidently inadequate to include even the most superficial view of the whole, I shall say a few words upon two of his theoretical researches on light, which have attracted most general attention. The first is upon the theory of Reflection and Refraction, framed so as to include the phenomena of metallic reflection; the second is upon the Dispersion of Light.

(557.)

Theory of reflection and refraction, including the case of metals.

M. Jamin.

I shall first mention some seemingly exceptional facts to the ordinary laws of polarization by reflection. As early as 1814 (*Philosophical Transactions*, 1814, p. 230), Sir David Brewster had remarked that such highly refractive substances as Realgar, Diamond, and Chromate of Lead, do not polarize, at *any* angle, the whole of the reflected light. Mr Airy afterwards showed that light reflected from diamond near the maximum polarizing angle, possesses qualities resembling those of light reflected from metals. The same view was more generally stated by Mr Dale;[5] and last of all, M. Jamin showed that all transparent substances polarize *elliptically* the light which they reflect,—the difference of "phase" of the two component vibrations increasing from 180° at a perpendicular incidence, to 360° at an incidence of 90°; and that the laws of reflection at transparent surfaces, as also in the case of metals, depend upon two constants—the *index of refraction* and the *coefficient of ellipticity.* And he has determined in numerous cases the values of these constants.

(558.) Fresnel's theory modified by Green and by M. Cauchy.

Thus Fresnel's theory of reflection requires undoubted modification. It only holds true for substances whose index of refraction is nearly 1·46, that of the glass which he examined. The complication is held to arise from the existence of vibrations (called *normal*) in the direction of transmission of the luminiferous wave, such as those which produce the effects of Sound in air, and which produce certain effects on Light at the bounding surfaces of two media. In the theory of Fresnel, as also in those of Maccullagh and Neumann, this influence is neglected. To Green and to M. Cauchy belongs the merit of laying down a more comprehensive theory. Mr Green's theory, published in 1837[6] (not long before his death), is so far incomplete that it involves only one constant. M. Cauchy's investigations, published two years later,[7] embrace the phenomena of metallic reflection by the introduction of the two constants mentioned above, thus completing the theory of reflection and refraction both for transparent and metallic surfaces.

(559.) Theory of dispersion.

The fact of the unequal refrangibility (dispersion) of light has ever been felt to be one of the most real as well as prominent difficulties in admitting the undulatory theory. That theory, in its simple form, enables us indeed to explain clearly enough the refraction of light owing to a change of velocity in the wave as it passes from one medium to another; but it assigns no reason why that change of velocity should be different for light of various colours, in other words, of different wave-lengths. The corpuscular theory, on the other hand, furnishes at least a plausible explanation, by assuming a variable attraction between refracting media and the molecules composing the different rays.

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[1] *Cambridge Transactions*, vol. ix.

[2] *Repertoire d'Optique Moderne.* 1847–50.

[3] *Handbuch der Optik*, Band i., 1839.

[4] *The Undulatory Theory as applied to the Dispersion of Light.* 1841.

[5] See Moigno *Rep. d'Optique*, p. 1385.

Green's account of his method.

[6] *Cambridge Transactions*, vol. vii. The following extract from this able paper shows the independence of physical assumptions which characterizes these ultra-mathematical optical theories:—". . . We are so perfectly ignorant of the mode of action of the elements of the luminiferous ether on each other, that it would seem a safe method to take some general physical [?] principle as the basis of our reasoning. . . . The principle selected as the basis of the reasoning contained in the following paper is this: In whatever way the elements of any material system act upon each other, if all the internal forces exerted be multiplied by the elements of their respective directions, the total sum for any assigned portion of the mass will always be the exact differential of some function. But this function being known, we can immediately apply the general method given in the *Mécanique Analytique*, and which appears to be more especially applicable to problems that relate to the motions of systems of an immense number of particles mutually acting on each other. One of the advantages of this method, of great importance, is, that we are necessarily led by the mere process of the calculation, and, with little care on our part, to all the equations and conditions which are *requisite* and *sufficient* for the complete solution of any problem to which it may be applied."

A consideration of the candid admissions of the preceding paragraphs (especially the last sentence) will lead the reader to see how short a way a theory of so general a kind—the chief characteristic of which consists in eluding every troublesome physical enquiry—can go towards explaining the relations of Light to Matter; yet it may be of use by indicating the kind of solutions which more restricted hypothesis may be expected to give of the laws of phenomena.

[7] *Comptes Rendus de l'Acad. des Sciences.*

(560.) Depends on the finite distances of the vibrating particles.

When, however, undulationists were pressed on the subject, it was easy to see the direction in which at least a plausible explanation might be sought. In the usual form of equation for vibrations in air, given by Lagrange, the integration is effected by assuming the intervals between the particles evanescent compared with the length of a wave. This is perfectly true in the case of sound, and all sounds appear in consequence to travel uniformly. But should it fail in the case of light, that is, should the intervals of the ethereal particles bear some sensible ratio to that very small quantity, the length of a wave, what would be the result? M. Cauchy has made out, by a very complex analysis, that in this case the longer waves will travel most rapidly, and consequently be least refracted. Several other writers, especially Professor Kelland, obtained similar results; and Mr Airy, by very simple, though only approximate, considerations, showed the dependence of refraction on the length of a wave.[1] M. Cauchy's memoir appeared in 1835 at Prague, in a bulky and abstruse form: the mathematical investigations are very long and complex, the numerical verifications scarcely less so.[2] The indices of refraction, observed by Fraunhofer, for different lines of the spectrum, in different kinds of glass, together with the corresponding wave-lengths for these rays, formed the principal data for comparison. But others have since been obtained by Rudberg and Professor Powell, and carefully compared with M. Cauchy's theory by the latter, and the coincidence appears satisfactory.[3] But in estimating the value of this coincidence, it is to be observed that of 7 indices of refraction observed for each substance, 3 must be used to ascertain the constants in the formula, and only 4 remain to be calculated.

(561.) Non-dispersion of light in free space.

One difficulty, however, remains. If the rays of light travel through space with variable velocities, the images of the stars would present tails of colour inconsistent with observation. M. Cauchy eludes this difficulty by the following hypothesis respecting ethereal media:—The existence of transversal vibrations (according to him) requires that the law of force between particle and particle of ether must not be intermediate between the inverse 2d and inverse 4th power of their distance. In the former case the force is an attractive, in the second a repulsive one. In the first, the velocity of propagation depends on the length of a wave, in the second it is independent of it. [The first case, too, alone will be consistent with permanent *longitudinal* vibrations.] Consequently if we suppose that in free space the particles of ether are arranged in close order, and exert a repulsive force on each other, no dispersion results; but in refracting media, supposing the distance of the molecules increased, and the mutual action attractive, then dispersion occurs.[4]

§ 7. RITTER.—*Chemical Rays of the Spectrum.*—NIEPCE; DAGUERRE; MR TALBOT. *Art of Heliography or Photography—Daguerreotype—Calotype.*—Professor STOKES. *Chemical Rays rendered visible—Fluorescence.*

(562.) Chemical action of light.

A very curious chapter of the history of Light remains to be written, respecting the chemical energies which it is capable of exerting, or which at least are found in those parts of the solar rays which are dispersed by a prism. These are in part luminous and partly invisible under ordinary circumstances, the latter possessing these chemical qualities in a still higher degree than the others. Though not perhaps very closely associated with the optical discussions of the previous sections, it seems impossible to separate this part of the subject from the rest, since the rays called Chemical may, as we have reason to think, be reflected, refracted, polarized, absorbed, and made to interfere like visible light; and farther, because to the extreme limit of their sensible action they may, by certain treatment, be made visible to the eye. The art of photography, though belonging quite as much to chemistry as optics, being a means of inquiry into the qualities of the solar radiations invaluable to the natural philosopher, cannot by any means be excluded from a sketch, however general, of the progress of physical science.

(563.) Ritter.

J. W. RITTER, Professor of Chemistry at Jena, and well-known for his numerous contributions to the earlier progress of voltaic electricity, has the merit of having first clearly pointed out in 1801 the separate existence of chemical rays in the spectrum which extend beyond the most refrangible or violet rays (when the sun's light is decomposed by a prism), in the same manner as the invisible rays of heat were found by Sir Wm. Herschel to extend beyond the visible red. Scheele had indeed previously noticed that the power of the sun's light to decompose and blacken salts of silver increased rapidly from the red towards the violet ray; and there is little doubt that Herschel's discovery suggested that of Ritter, of the independent or non-luminous rays of the spectrum.

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[1] In all these cases the expression for refrangibility depends on the ratio of the sine of an arc to the arc itself; which are again includes the ratio of Δx, the distance of the molecules to λ, the length of a wave. When Δx becomes very small, the first ratio becomes unity.

[2] A portion of these researches had, however, been printed in Paris (privately, I believe) in 1830.

[3] Powell on the Undulatory Theory. 1841.

[4] Moigno, *Repertoire d'Optique*, p. 128.

(564.) Chemical rays of the spectrum.

Ritter attributed to these rays a *deoxidizing* quality. Dr Wollaston, who also made experiments on the subject, and discovered the specific action of the different rays on gum-guiacum, prudently suggested the more comprehensive term of *chemical* rays. Various other denominations have been proposed, which need not be here dwelt upon; all that can be said is, that deoxidation does not represent the solar action completely. Whether it be really an independent principle in the sun's rays which causes these effects, or merely light and its modifications, is, as in the corresponding case of heat, yet undecided. But it is remarkable that, as shown by M. E. Becquerel, the discontinuity of the luminous spectrum producing "Fraunhofer's Lines" exists equally for the chemical rays.

(565.) They interfere; and may be polarized.

Soon after Ritter's first experiments, Dr Young proved the Interference of the obscure chemical rays (*Phil. Trans.*, 1803), a conclusion successively claimed since by different physicists. Berard in 1812 showed that these rays are polarized by reflection. Seebeck observed that the different rays impressed different colours upon salts of silver: and M. Edmond Becquerel long afterwards showed that the red and yellow rays, though incapable of commencing chemical action, in some instances have the power of *continuing* it when once excited by the more refrangible rays.

(566.) Mrs Somerville's experiments.

In 1835 Mrs Somerville made some interesting experiments on the permeability of different bodies to the chemical rays, similar to those of Melloni on the heating rays (see chap. VI., § 8), and she found great and seemingly capricious variations in this respect.[1] The account of them was addressed to Arago, and published in the proceedings of the French Academy. She found that green glass, coloured by copper, intercepted entirely the chemical rays, yet this was not due so much to its *colour* as to its other qualities (which are also peculiar as regards radiant heat), for the emerald transmits the same rays. Red glass stops most of the chemical rays, whilst the garnet transmits them. Though white glass has generally been considered very transparent for these rays, Mr Stokes has shown that it entirely stops those of the *very highest* refrangibility, which are readily transmitted by quartz. Sir John Herschel and Mr Hunt have made many interesting experiments with coloured media on the particular parts of the chemical spectrum absorbed, but a great deal remains to be done, especially as regards the nature of the substances employed.

(567.) History of photography.

But the great impulse given to this subject was derived from the invention or discovery of the beautiful art of PHOTOGRAPHY.

(568.) Wedgewood and Davy.

In 1802 Mr Thomas Wedgewood and Sir Humphrey Davy succeeded in forming pictures of objects laid on paper prepared with nitrate of silver, and in taking profiles (*silhouettes*) by means of shadows. They proposed to obtain similar effects by means of the camera obscura, but their paper was not sufficiently sensitive. The effectual bar to their proceedings was, however, this: that they could discover no means of *fixing* the shadows which they had obtained, or preventing the whole surface of the paper from being gradually blackened by exposure to light.

(569.) Nicephore Niepce.

In 1814 J. NICEPHORE NIEPCE, a retired proprietor at Chalons sur Saone,[2] entered into a similar enquiry, but by methods quite different. He employed the solar effect upon resinous bodies, and some at least of his pictures were executed on plates of pewter or of rolled silver. They were mostly copies of engravings, and the light parts corresponded to the lights of the originals. He, however, at length succeeded in fixing impressions of views in the camera obscura, though in an imperfect manner, and after very long exposure. The pictures thus obtained had this in common with more perfect processes, that the luminous impression was first brought into view by a chemical process *subsequent* to exposure in the camera. In 1825 Nicephore Niepce became associated with Daguerre, who had previously been engaged in the same research; they agreed to communicate the results of their several experiments. The result, as is well known, was the invention of the DAGUERREOTYPE, not improperly called after Daguerre, who seems really to have worked it out almost entirely for himself, after the death of Niepce in 1833; whilst so patient and determined was Daguerre in

Daguerre.

Mrs Mary Somerville — magnetic action of light [?].

[1] The maiden name of this accomplished lady was Mary Somerville; she was born, I believe, at Jedburgh, and married first Mr Greig, afterwards her relative Dr Somerville. She is known in British science not only as the able commentator of Laplace's *Mécanique Celeste*, but as the author of some ingenious and apparently convincing experiments on the magnetizing power of the *violet* ray. Some anomaly, however, remains to be explained on this subject, as the result cannot always be obtained. Several years before Dr Faraday made his discovery of what he terms the "magnetization of light" (see chapter vii., § 5), the writer of these pages supposed that the reaction of light and magnetism, observed by Morichini and Mrs Somerville, might be due to a latent and casual polarization of the light which was not present in all the experiments; and, in particular, he suspected that circularly polarized light might have a magnetic influence; but his experiments to this effect, in May 1836, were not successful, though he thinks them worth repeating.

[2] Probably one of the MM. Niepce who, in the early part of the century, are said to have propelled a boat on the Saône by a peculiar kind of air-engine, called *pyreolophore*. Delambre, *Rapport Historique*, 1810, p. 242.

keeping his secret until brought to perfection, that he did not even show his results until early in 1839, when the numerous specimens he had to exhibit rivalled in delicacy anything that the art has since produced.[1]

(570.) The daguerreotype.

The daguerreotype is depicted in the camera on a plate of silver, coated with an evanescent film of iodide, by exposure for a short time to the vapour of iodine. After the light has acted, and the plate has been withdrawn from the camera, no trace of a picture is visible until it has been exposed to the vapour of mercury, which, by its peculiar action on the places where light has acted, produces a correct picture of the object (or *positive* image, as it is called, light answering to light). It is then *fixed*, as it is called, by a bath of dissolved hypo-sulphite of soda, which has the property of removing the iodide of silver wherever the light has not acted. This singular and elaborate process has since been but slightly modified by various plans for rendering the iodide more exquisitely sensitive. To M. Niepce belongs the credit (1) of having fixed an impression of light, (2) of using metal plates, (3) of forming a picture by means of a camera obscura; to Daguerre, on the other hand, the novel and ingenious use of vapours instead of washes, and the whole succession of operations in the daguerreotype. When the French government acquired for the public (the French public, however, only) a right of property in the invention, they marked their sense of the share of merit of the inventors, by awarding to Daguerre 6000, to M. I. Niepce 4000 francs per annum.

(571.) Mr Fox Talbot—the calotype.

Mr W. H. Fox Talbot, a Wiltshire gentleman of great ingenuity and perseverance, and well acquainted with mathematics and physics, applied himself in 1834 to the problem of fixing shadows, in entire ignorance of what Wedgewood and Davy had attempted. He used paper washed with the nitrate of silver, and soon succeeded in obtaining impressions of lace and leaves of plants, but without *fixing* the shadows. This great step he, however, made a year or two later: a wash of iodide of potassium, or of common brine, was found to effect it. The announcement of his success and of his methods was called forth early in 1839[2] by the first reports of Daguerre's discovery. His method then consisted in dipping writing paper alternately in nitrate of silver and common salt, drying between the operations, and afterwards fixing the image. An unnatural or *negative* picture was thus obtained, the lights of nature being darkened on the paper, and *vice versa;* but the truth was restored by pressing the drawing thus obtained against a second prepared sheet of paper, and exposing it to light, when the natural lights and shades were of course obtained. This derived impression is called a *positive.* This process has evidently several advantages over Daguerre's;—such as, that paper is used instead of metal plates; and that from a single impression (*negative* from nature) copies may be at leisure indefinitely multiplied. Pictures were thus obtained by Mr Talbot with the camera obscura.

(572.) Progress.

Mr Talbot's chief improvement on his first method he called the Calotype (1841), and consisted in washing the paper successively with nitrate of silver, iodide of potassium,[3] and gallo-nitrate of silver. It is then exposed in the camera, *but no impression appears* until again washed with the gallo-nitrate of silver. It is then fixed with bromide of potassium, or with hypo-sulphite of soda, as in Daguerre's process.

(573.) Instantaneous process.

By a subsequent invention, Mr Talbot has obtained what he justly calls *an instantaneous process.*[4] An image was formed in a camera of a revolving wheel, to which was affixed a printed bill; the room being darkened, and the wheel made to revolve with the speed of 200 revolutions *in a second*, and being then illuminated by an electric spark, a legible impression of the printing was obtained. We doubt if, in the whole history of physics, a more astonishing result is recorded. Thus Mr Fox Talbot, by his rare energy, brought his inventions almost to perfection. Numerous competitors, of course, appeared on the field, and obtained many interesting results. The only one of much importance to the art of photography is the substitution of a film of iodized collodion on a glass plate, for the prepared paper in the first or *negative* process.

(574.) Analogy of the two processes.

The daguerreotype and calotype processes, though seemingly so different, have much in common:—(1) a sensitive surface has to be prepared (iodide of silver is the basis in both); (2) it is exposed in the camera; (3) the picture (still invisible) is developed; (4) it is *fixed*. In the calotype the *printing* process for obtaining *positives* must be added to these.

(575.) Chemical theory imperfect.

The chemical theory is very far behind the art of photography. The most important steps of these curious and complicated processes have been attained by a kind of divination after a multitude of failures. The salts of silver are of a highly decomposable nature, the iodides and bromides peculiarly so. The action of light appears to be to *reduce* the metallic silver, at least partially, an operation which is completed in the daguerreotype process apparently by the affinity of the mercurial vapour for iodine and for oxygen.[1]

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[1] The present writer had the benefit of seeing Daguerre's marvellous productions, and making his acquaintance at Paris, through the courtesy of M. Arago, while the secret was still preserved, and the public interest was excited to the highest pitch. About the same time he saw M. Isidore Niepce, son of the first photographer, and the specimens in his hands, as well as those in the possession of Mr Bauer of Kew, with whom they had been left by M. Nicephore Niepce, when he visited England in 1827 and exhibited them at the Royal Society. One of the latter was *engraved* on a plate resembling pewter.

[2] Communicated to the Royal Society of London, 31st January, and printed in the *Philosophical Magazine* for March.

[3] Mr Talbot says (*Phil. Mag.*, March 1839, p. 203) that Sir H. Davy had recommended iodide of silver as a sensitive substance; but in his earlier experiments he had found it the contrary. But now, like Daguerre, he requires no immediate visible action of light, but *developes* it by a subsequent reaction.

[4] The process is described in *Hunt's Researches on Light*, 2d edit., p. 140.

(576.) Importance of the photographic art.

If anything were wanting to show the impossibility of separating the scientific arts from the history of science itself, it would be the case before us. The art of photography is far in advance of the theory, yet it constitutes in itself the greater part of what we know in a highly interesting branch of Natural Philosophy—the chemical agency of the spectrum. The surfaces of Talbot and Daguerre are the philosophical tools by which farther discoveries can alone be made.

(577.) Chemical rays rendered visible.

So intimately connected with the discovery of the Chemical Rays of the spectrum, is that of revealing their existence (at least the existence of rays of the spectrum equally refrangible with those possessing chemical properties) to the sense of sight, that we may conveniently include in this section a very brief notice of Professor Stokes' remarkable experiments.

(578.) Professor Stokes.

Mr George Gabriel Stokes, a fellow of Pembroke College, Cambridge, and senior wrangler in 1841, at present holds the distinguished position of Lucasian Professor of Mathematics. It is almost needless, therefore, to state that his mathematical talents are generally acknowledged, and that he has displayed them by a ready application to many difficult problems in optics and mechanics which had not previously been accomplished. I may refer, however, to the integration of complex differential equations occurring in the theory of the flexure of solids (see art. 364), and in that of the rainbow (466), and in his elaborate investigation of certain cases of the friction of fluids (416). But it is more to our present purpose to observe that he combines this profound and technical command of analysis with singular skill in the experimental department of optics;—not merely in investigations closely connected with the wave theory, and expressible by mathematical formulæ,[2] but in those which depend on the judicious questioning of nature by critical experiments not necessarily quantitative;—such, in short, as Newton discusses in his *Optics;* and indeed since Newton himself occupied the Lucasian chair, there have been perhaps few philosophers who have shown so remarkable an aptitude for both kinds of research.

(579.) Shows that the refrangibility of light may be changed.

In 1852 Professor Stokes announced that the refrangibility of light, which has hitherto been considered its most inherent and invariable quality, may in some circumstances be altered. The fundamental experiment is this:—A beam of solar light is caused to form a pure and highly dispersed spectrum by passing through two or three prisms in succession, associated with a lens. The spectrum is made to fall on a glass vessel containing a solution of sulphate of quinine (a colourless fluid). Whilst the red, orange, and indeed the greater part of the luminous spectrum, pass through as if the fluid had been merely water, from about the middle of the violet "the path of the rays is marked within the fluid by a sky-blue light, which emanates in all directions from the fluid, as if it (the medium) had been self-luminous." This appearance extends far beyond the visible violet, the presence of the invisible rays (called chemical) becoming disclosed by the reaction of the quinine; and the dark bands, both of the visible and the (usually) invisible spectrum, are marked by *obscure planes* traversing the mass of diffuse light. When the light thus emanating from the interior of the quinine is examined by a prism, it is found to consist of rays of various colours and refrangibilities corresponding to those of the ordinary spectrum; from which Mr Stokes concludes that, since only violet rays and the invisible rays beyond them could have furnished or excited this emanation, the rays of light themselves have been transformed into others, with a lower degree of refrangibility, and possessing the corresponding optical properties. In conformity with this explanation, Professor Stokes has considered and accounted for a number of curious phenomena described by Sir David Brewster and by Sir John Herschel; called by the former "internal dispersion," by the latter "epipolic dispersion," all of which, so far as they involve anything peculiar, may be reduced to the general principle that certain bodies by their action on light have the power of *lowering the refrangibility* of the rays incident upon them, whether belonging to the visible or invisible spectrum—that is, of emitting rays of a lower, while under the excitement of rays of a higher refrangibility. Hence the phenomenon has been termed the "degradation" of light. Mr Stokes has also called it "*fluorescence*," a word involving no hypothesis, being derived from the characteristic action of a certain kind of fluor-spar described by Sir David Brewster.

Fluorescence.

(580.) Substances possessing this property.

Many substances, solid and fluid, are found to possess these qualities.[3] Amongst others, and in the highest degree, glass coloured yellow by oxide of uranium, called in commerce *canary glass*, and solutions of horse-chestnut bark.

(581.) Remarkable experiment with electric light.

By using sources of light richer than sunlight in the highly refrangible rays; by also using quartz for the prisms instead of glass (which has the power of absorbing these to a considerable extent)—Professor Stokes has obtained a result truly astonishing. In the case of the light derived from a voltaic arc, produced by the battery of the Royal Institution with metallic poles, the visible spectrum formed upon uranium-glass extended no less than *six or eight times* the length of the ordinary spectrum. If, by way of contrast, a porcelain tablet be used as a screen, the spectrum terminates at the usual point.[1]

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[1] I may refer to a short but clear paper on the theory and practice of photography by the Rev. W. T. Kingsley, in the *Journal of the Photographic Society*, vol. i., August 1853. Mr Kingsley is one of the most scientific and practical improvers of the art.

[2] This he has also done in a beautiful paper on the effect of polarization in modifying the phenomena of diffraction. *Camb. Trans.*, vol. ix.

[3] The greater part of these had been detected by Sir D. Brewster, with his usual acuteness and perseverance, in the course of his researches on "internal dispersion." The colouring matter of green leaves is one of the most remarkable.

(581.) Mr Wheatstone on vision—the Stereoscope.

[I have already (art. 471) expressed my regret that the limits of this Essay prevent me from devoting a section to the physiological part of Optics; but I cannot close the chapter without at least naming Mr Wheatstone's beautiful invention of *the Stereoscope*, as by far the most interesting contribution recently made to the theory of vision, regarded in a point of view not strictly anatomical. Although Mr Wheatstone's paper was published in the *Philosophical Transactions* for 1838, and the Stereoscope became at that time known to men of science, it by no means attracted, for a good many years, the attention which it deserves. It is only since it received a convenient alteration of form (due, I believe, to Sir David Brewster), by the substitution of lenses for mirrors, that it has become the popular instrument which we now see it, but it is not more suggestive than it always was of the wonderful adaptations of the sense of sight.]

CHAPTER VI.

HEAT, INCLUDING SOME TOPICS OF CHEMICAL PHILOSOPHY.

§ 1. BLACK.—*Latent and Specific Heat.*—Irvine.—Hutton.—*Doctrines of Heat applied to some Natural Phenomena.*

(582.) Heat considered in the 18th century as a branch of chemistry.

Down to the close of the 18th century, the science of Heat was studied and advanced mainly by chemists, and it was in all respects treated as a branch of Chemistry; a position of which we still find traces in the introduction of the doctrines of heat (even of radiant heat) into most of our approved treatises on Chemistry. This circumstance brings us, in this chapter, into close contact with the most illustrious chemical names of the second half of the last century and of the first years of the present. Such were Black, Cavendish, Lavoisier, and Dalton. Of the last and two first it may be doubted whether they were not as prominent discoverers in Physics as in Chemistry. Davy occupies a similar position. It was not, indeed, until the 19th century had made some progress that Chemistry assumed a strongly distinctive position of its own, and began to attain that large development and complex character of detail which render it a science now hardly accessible to those who do not devote to it their almost undivided attention. In the days of Black and Cavendish it was otherwise; and in the first section of the present chapter I shall attempt to give an outline of the characters of the very remarkable men who then advanced simultaneously the doctrines of Physics and Chemistry; referring, of course, chiefly to the former, but not entirely to the exclusion of the latter portion of their researches, particularly with respect to the atomic and gaseous theories of Dalton, which have a strongly physical aspect. I have elsewhere noticed the barrenness of the greater part of the 18th century in contributions to the experimental sciences; the temptation is therefore the greater to dwell a little even on the personal history of men so celebrated and influential as Black, Cavendish, and Dalton.

(583.) Black—his eminence as a chemist.

JOSEPH BLACK was born at or near Bordeaux in France, in 1728. His biography, little eventful and almost exclusively academic, has been recorded in some detail by his companions and friends Adam Ferguson and John Robison (the former of whom was a relation), in the preface to the posthumous publication of his Lectures on Chemistry. It is sufficient for me to state that he entered the University of Glasgow as a student in 1746. Being destined for the medical profession, he removed in 1750 or 1751 to Edinburgh, where he benefited especially by the lectures of Cullen, a most eminent physician, and the author of a beautiful experiment on the cold produced during evaporation. Before Black graduated (in 1754) he had entered upon a course of chemical experiments connected with the causticity of many earthy bodies, which ended in his first (and perhaps most famous) discovery of the existence of *fixed air* or carbonic acid gas as an essential constituent of marble and other solids, together with a train of important consequences. Few inaugural dissertations have been so interesting to science as that on Magnesia, printed at Edinburgh in 1754, which contained these results. But on this purely chemical question we will not enlarge.

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[1] On Mr Stokes's experiments, see *Phil. Trans.*, 1852-53; and Proceedings of the Royal Institution.

(584.) His discoveries of latent and specific heat.

Latent heat absorbed in melting ice.

Its amount.

The discoveries of Black with which we are chiefly concerned are those of latent and specific heat. The former, at least, is Black's sole and exclusive property. When we look back to the state of the science of heat in the first half of the 18th century, we are surprised at the exceeding slowness of its progress. The thermometer had been improved by the use of the freezing and boiling temperatures of water for its fixed points, and the adoption of mercury in its construction by Fahrenheit; the correspondence of its scale with true increments of heat had been tested, though imperfectly, by Brooke Taylor; and Dr Martine of St Andrews had published an ingenious work (the best of its period) on the expansion of different liquids, and on some kindred subjects; but in general no great step was made until Black, in 1757, or previously,[1] concluded that during the melting of snow or ice, a great quantity of heat enters into the body without affecting the thermometer in an appreciable degree. The heat therefore spends itself or is absorbed in effecting liquefaction. Black called it *latent* (as opposed to *sensible*) heat. He was led to this discovery by the very simple observation of the extreme slowness with which ice is melted by the application of an amount of heat which would have raised the temperature of water to an enormous extent; the thermometer plunged in the thawing ice remaining stationary until it is entirely reduced to water. When that occurs, heating immediately commences according to the usual laws. One of Black's original experiments clearly illustrates his mode of procedure. He suspended equal weights of ice at 32°, and of water as near as might be at the same temperature, in two thin glass vessels 18 inches apart, in a spacious room having a temperature of 47°. The vessel containing water rose 7° in temperature in half an hour, but the equal weight of ice had not wholly melted, nor had its temperature even slightly increased until 21 half hours had elapsed. Whence Black concluded (approximately) that as much heat is requisite merely to thaw ice as would raise an equal weight of water through 7 × 21 or 147°; a result almost corrrect, although the experiment in this form is manifestly not unexceptionable. The converse process of freezing shows how prolonged must be the application of cold to discharge water at 32° of its latent heat, or heat of liquefaction, and to convert it into ice.

(585.) Consequences.

Nothing is more admirable in these results than the light they throw upon certain natural processes. Were instant liquefaction the result of the smallest application of heat to snow at 32°, we should many times a year be the victims of uncontrollable floods; and did water instantly become ice on its temperature reaching the freezing point, our lakes and rivers would be rapidly consolidated to the very bottom on occasion of every frost, and animal life would be impossible.

(586.) Latent heat of vapour.

Experiments of Irvine and Watt.

The analogy of the gradual formation of steam in boiling, to the gradual liquefaction of ice, was so evident as to lead Black to conclude, without any special experiment, that a great deal of heat becomes *latent* during the conversion of liquids into vapour. It appears to have been in 1762 that he attempted to determine roughly the amount, by a method similar to that just described for the heat of liquefaction. He compared the time required under the action of a uniform source of heat to raise the temperature of a certain quantity of water from 50° to the boiling point, with that required to boil it away; and inferring that heat was continually combining with the water at the same rate, he estimated the latent heat, or heat of vapour, to be as great as would have raised the temperature of the water had that been possible by 810°. This was in October 1762;[2] about two years later his pupil, Irvine, made experiments under his direction with a still and refrigeratory, by which he estimated the heat given out by steam during its reconversion into water. Mr Watt prosecuted the same inquiry soon after.[3] How happily Mr Watt applied the doctrine of latent heat thus brought experimentally under his notice, to the improvement of the steam-engine, has been already recorded.

(587.) These laws singularly overlooked before Black.

One thing strikes us very much on a review of these discoveries of Black; it is the great interval which separates the clear perception of a fact from the explanation of it; or, in other words, from the clear expression of the more general fact which embraces it, although when once given, the explanation may seem to be *almost* expressed in the very enunciation of the fact. Nearly a century before Black, the lynx-eyed Hooke had noticed that water during the process of congelation remained unaltered in temperature, and that the same takes place when it boils, and this observation had been numberless times verified in ascertaining the fixed points of thermometers; yet no one before Dr Black had even guessed that the heat which enters into ice during liquefaction, and into water during vaporization, remained as it were a constituent of the water and the steam thus formed, and could at any time be recovered by a converse process. Numberless instances occur in the history of science in which it requires the utmost attention to appreciate the importance and difficulty of drawing such seemingly obvious conclusions.

(588.) Specific heat.

The other great discovery of Black, Specific Heat, was in like manner a correct interpretation of a fact already known. Boerhaave and Fahrenheit had found that when quicksilver and water were mixed together, their temperatures being different, the heat of the mixture was not, as might have been expected, the average of that of its ingredients, whether the volumes or the weights of those ingredients were equal. "Quicksilver, whether it were applied hot to cold water or cold to hot water, never produced more effect in heating or cooling an equal measure of the water than would have been produced by water equally hot or cold with the quicksilver, and only two-thirds of its bulk." Of course, when equal weights were used, the inequality of effect was still more striking, for, from the great density of quicksilver, it required no less than 30 times the weight of the water mixed with it in order that it should contribute in an equal degree to the production of a mean temperature. Strange to say, the interpretation of this important experiment remained to be made by Dr Black after half a century. He taught that temperature is an effect of heat, which is neither the same in all bodies nor in the same body under differing circumstances; that the superior effect of the water to the mercury in determining the temperature of the mixture was caused by the fact, that it is the nature of quicksilver to require a smaller amount of heat to raise its temperature through one degree than an equal volume or weight of water would require under like conditions. Black made many experiments to satisfy himself of the constancy of this property in bodies; and with the assistance of Irvine,[1] probably ascertained its numerical value (the amount of heat necessary to raise an unit of mass of water through one degree of temperature being the standard) in different cases; but he left the subject chiefly in the hands of that observer and of Watt. The former gave the name of *capacity for heat* to this property, which was afterwards more happily termed *specific heat* by Gadolin, who made many experiments on the subject, as did also Cavendish and Adair Crawford whose theory of animal heat, published in 1778, turns entirely on this property of bodies.

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[1] On the authority of a letter from Black to Watt; see Black's *Lectures.*

[2] Black's Lectures, i., 158.

[3] Ibid., 171–173. In these early experiments the latent heat of steam was a good deal underrated.

(589.) Irvine's theory of capacity of bodies for heat.

Irvine had the merit, such as it was, of proposing a theory on which his term *capacity for heat* was principally founded, which occasioned for many years after, although now comparatively forgotten, much discussion. He assumed that the changes in the temperature of bodies, whether by alteration of their mechanical condition or by chemical combination, were due to a change in the capacity for heat of the substance or the mixture. He also assumed that the total amount of heat contained in a body is proportional to the amount of heat necessary to raise its temperature through one degree (for example, a pound of mercury contains altogether one-thirtieth part of the entire heat contained in a pound of water). From these principles he deduced the temperature of absolute zero or privation of heat as follows:—When sulphuric acid and water are mixed together, the temperature rises. This rise, according to him, is caused by the capacity for heat of the mixture being less than the average due to its ingredients. He has, therefore, got the ratio of the whole heat in the bodies before mixture and after mixture. He has also got the number of degrees of temperature corresponding to this difference. Having the ratio of these quantities, and also their difference, the quantities themselves, or the whole amount of heat expressed in degrees of temperature before and after mixture, become known, and the temperature of absolute privation of heat is also known. He applied the same reasoning, with great ingenuity, to explain the latent heat of liquids and vapours, which he ascribed to their increasing capacities. He thence deduced other values for the absolute zero; but whereas all these determinations ought to have agreed, at least approximately, they were found by later experimenters, especially by Lavoisier and Dalton, to differ so widely—even by several thousand degrees—that, since the time of the latter, this ingenious theory has been nearly abandoned, at least as far as the search after the zero is concerned; although undoubtedly change in the specific heat of bodies is often an important element in determining their temperature.

(590.) Black as a lecturer—his character.

To return to Dr Black. From 1756 to 1766 he filled the chair of Chemistry and Medicine at Glasgow, where he also practised as a physician. In 1766 he left Glasgow for Edinburgh, to succeed Dr Cullen as Professor of Chemistry—a position which he held, with great credit to himself and with benefit to the University, till his death in 1799. His health, during the greater part of that time, was feeble, owing to a pulmonary affection, which often interrupted his lectures, and, it is stated, prevented him from engaging in severe study without immediate injury. Though he published one or two papers during these thirty years, they were of comparatively trifling importance. His influence on science was chiefly exerted through the medium of his pupils and of his intercourse with general society. His lectures are described by those who had the good fortune to hear them as inimitable of their kind—grave, dignified, and so interesting as to rivet the attention. "Perfect elegance as well as repose was the phrase by which every hearer and spectator naturally, and as if by common consent, described the whole delivery."[2] It is probable, also, that in his private intercourse with his pupils, he inspired them with that love of research which distinguished his own early days, and his taste for neat and accurate experiment could hardly fail of being imparted to a certain extent. Yet we may be permitted to regret that his constitutional indolence, almost apathy, had perhaps as great a share as bad health in the interruption of his career of discovery. Even when quite a young man, his most interesting conclusions were so gradually evolved, that he himself had difficulty afterwards in fixing their date; and some of them were delayed even for years, until he found time to make the requisite experiments. So cool a temperament was not likely to grow warmer as age advanced. Almost as indifferent to the honours of discovery as his stoical contemporary Cavendish, unlike him he enjoyed in a high degree intercourse with the congenial society which Edinburgh at that time afforded. He loved to converse infinitely better than to write; especially when he could converse intimately with such men as Adam Smith, David Hume, Adam Ferguson, Principal Robertson, Dr John Robison, John Home, Clerk of Eldin, and Dr James Hutton.

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[1] Sir J. Leslie has, I think inadvertently, given the credit of the *discovery* of specific heat to Dr Irvine.

[2] Lord Brougham.

(591.) Dr Hutton—Black's intimate friend—his theory of rain and vapour.

Hutton was perhaps Black's dearest friend, and may be mentioned here (episodically) as no ordinary thinker in Natural Philosophy, as well as in Geology and Metaphysics. Besides the "theory of the Earth," which will ever bear his name, and which, after various transmutations in name and form, is now by far the most widely prevalent, his theory of Rain was an ingenious and important speculation. Other branches of Meteorology also claimed his attention, particularly, as might have been expected, those which are connected with the temperature of the earth. He was one of the first who drew conclusions from the temperature of springs, with regard to change of climate due either to increased latitude or to increased height above the sea. His hygrometer, in which the dampness of the air was estimated by the coolness due to evaporation, was unquestionably the first suggestion of a method now in general use. His ideas on the constitution of matter were bold and ingenious, though not on all points tenable. They resembled those of Boscovich, though independent of them. He published a voluminous treatise on several subjects in Natural Philosophy, and a still more formidable one on the Principles of Knowledge, neither of which attracted much attention at the time, and have been long forgotten; yet it is not unlikely that some of his speculations in metaphysics might be worth the labour of reexamination. His friend and commentator, Playfair, (whose style was as remarkable for perspicuity as Dr Hutton's was the contrary) has drawn the following lively contrast between the characters of Hutton and Black, which may properly conclude this notice:—

Contrast of Black and Hutton.

"Ardour and even enthusiasm in the pursuit of science, great rapidity of thought, and much animation distinguished Dr Hutton on all occasions. Great caution in his reasonings, and a coolness of head which even approached to indifference, were characteristic of Dr Black. On attending to their conversation, and the way in which they treated any question of science and philosophy, one would say that Dr Black dreaded nothing so much as error, and that Dr Hutton dreaded nothing so much as ignorance; that the one was always afraid of going beyond the truth, and the other of not reaching it. The curiosity of the latter was by much the more easily awakened, and its impulse most powerful and imperious. With the former, it was a desire which he could suspend and lay asleep for a time; with the other, it was an appetite that might be satisfied for a moment, but was soon to be quickly renewed. . . . . Each had something to give which the other was in want of. Dr Black derived great amusement from the vivacity of his friend, the sallies of his wit, the glow and original turn of his expression; and that calmness and serenity of mind which, even in a man of genius, may border on languor and monotony, received a pleasing impulse by sympathy with more powerful emotions."[1]

(592.) Black's death.

Black died on the 6th December 1799.[2] His death, as recorded by his kinsman, Adam Ferguson,[3] was one of the most touching on record. It succeeded his customary state of health by an interval inappreciably short, and, as appeared by the accompanying circumstances, without the slightest physical emotion. The philosophic composure of his whole life was mirrored in the serenity of its close.

§ 2. Cavendish.[4]—*His Singular Character and Attainments—Eminent Chemical Discoveries—Observations on Heat and on other Branches of Physics*—Lavoisier—*The Calorimeter—Theory of Combustion and of Oxidation.*

(593.) Cavendish.

Cuvier has justly remarked, in his biography of Cavendish, that he had to struggle in his scientific career against obstacles much more rarely encountered, and perhaps less easily overcome, than those which beset the progress of genius cramped by poverty and neglect. Cavendish was the descendant of one of England's noblest families, and he was likewise the possessor of enormous wealth; yet neither of these powerful temptations could withdraw him even for an hour from the course of study which he had marked out; and which constituted for him at once labour and relaxation, the end of living, and almost life itself.

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[1] Playfair's Biographical Account of Dr James Hutton, *Works*, vol. iv.

[2] Muirhead's *Correspondence of James Watt*. Introd., p. xxii.

[3] Preface to Black's *Lectures*, by Robison, p. lxxiv.

[4] I find an apology almost necessary for introducing at some length the biography of Cavendish into a chapter professedly on Heat, his positive discoveries connected with which were less notable than in some other departments. But besides that his position in the first rank of chemists naturally indicates his place to be between Black and Dalton, I felt a wish to bring out the *relief* of the striking intellectual characteristics of those three remarkable men, by placing them in juxtaposition. I may add that these three sections were the earliest written of this Dissertation, at a time when I had hoped to interweave into its composition more of the purely biographical character of each period of scientific history than I found it afterwards practicable in all instances to carry out. I trust, however, that it may be found a not unwelcome variety amidst the abstruser details of science. In the case of Cavendish, too, so various are his claims on our notice, that it was inevitable to recur to them in different chapters, especially in those on Astronomy and Electricity. It was not, therefore, really material under which head the more strictly personal details were given to which I have alluded.

(594.) His personal history. The Honourable Henry Cavendish, son of Lord Charles and Lady Anne Cavendish, was born at Nice, October 10, 1731.[1] He entered St Peter's College, Cambridge, 24th November 1749, where he resided during the usual terms for above three years, when he ought naturally to have graduated, which, however, he never did. That he had pursued at least his mathematical studies with ability and success is, however, nearly certain from the firm hold which he ever after retained of them. He joined the Royal Society of London in 1760, and published his first paper in their *Transactions* in 1766. From the time of his leaving Cambridge for some years his personal history is not known, though he probably resided in London.

(595.) His wonderful range of scientific knowledge. The subsequent history of Cavendish is the history of his studies and his discoveries. The latter were published in concise memoirs, written with scrupulous precision, and all printed in the *Philosophical Transactions.* If collected (which they have not been) they would fill but an insignificant volume, yet include all the requisites to establish a first-rate reputation. His studies no doubt were enormous, for they occupied every disposable moment of a life prolonged almost to fourscore. They may be guessed at (in addition to the published results) from his manuscript remains, a few of which have been edited recently, but the larger part remains in manuscript in the possession of his heirs. Few if any branches of exact science were unfamiliar to him; and his published papers include astronomy, mechanics, electricity, heat, chemistry, and meteorology, besides which he cultivated mathematics and geology. His reputation is one of those which may be called in a peculiar sense European or universal, because it marked a great epoch in science to which the publication of his writings materially contributed. That epoch was when chemistry became a science of *weight and measure.* Cavendish was a weigher and measurer almost by nature, and entirely so by habit. It appears from his note-books that he took the most scrupulous pains to ascertain and record the quantities of the ingredients employed in every experiment, even though they might be immaterial to the result; and his whole life was methodical in the same proportion. The immense importance of Cavendish's labours to the progress of science in his day is found in the unanimous testimony of his contemporaries; and notwithstanding the extreme retirement in which he lived, and the rarity of his appearances as an author, he was generally regarded as perhaps the leading man of science in England of his day; and his good opinion was considered by contemporary philosophers as their highest praise. Sir Humphry Davy's opinion of him (recovered and published by Dr Davy from a manuscript lecture) represents that of such of his countrymen as were qualified to form one, and the writer of it was usually fastidious in his judgments of others:—"It may be said of Mr Cavendish, what can perhaps hardly be said of any other person, that whatever he has done has been perfect at the moment of its production. His processes were all of a finished nature. Executed by the hand of a master, they required no correction; and though many of them were performed in the very infancy of chemical philosophy, yet their accuracy and their beauty have remained amidst the progress of discovery, and their merits have been illustrated by discussion, and exalted by time."

(596.) Chemical discoveries of Cavendish. After this eulogium of so competent a judge, I shall be satisfied by a simple enumeration of those chemical discoveries which were the most splendid results of his career, but which hardly come within the immediate scope of this dissertation. To him we are mainly or entirely indebted for the knowledge of hydrogen as a distinct elastic fluid or gas; of the exact constitution of the atmosphere, and the wonderful constancy of its ingredients; of the composition of nitric acid; and finally, according to the opinion of most persons (at least till lately), of the non-elementary nature of water, and of its precise constituents. This last and crowning discovery has indeed been contested, and made the subject of a prolonged and bitter scientific controversy, which hardly could be said to exist until the contemporary generation who witnessed the facts, and also the succeeding one, had passed away. For Cavendish received until his death, and for nearly thirty years after, the unquestioned tribute of at least the primary merit in so great a step in science. The topics more peculiar to the present essay (sufficiently extensive besides) enable us to dispense with the unwelcome task of once more analyzing a controversy purely personal, and which has almost filled volumes. I shall content myself with stating two considerations, which must have great weight in turning the balance of the evidence (supposing it balanced) in Cavendish's favour. The first is founded on the behaviour of Watt himself; the second on the known character of Cavendish.

(597.) Controversy on discovery of the composition of water. As to the former consideration, I would remark that Watt withdrew the letter to Priestley which he had submitted to the Royal Society and which contained his views respecting the composition of water, before it had been read at the meetings of that body.[2] The causes of this suppression are candidly stated by Watt in a letter to Sir Joseph Banks, published by Mr Muirhead,[3] in which he states that he "thought

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[1] *Life of Cavendish*, by Dr George Wilson; a valuable biography, which has been printed in the series of publications of the "Cavendish Society," and thus unfortunately has had but a limited circulation.

[2] *Correspondence on the Composition of Water*, p. 30.

[3] *Ibid.* p. 52.

Argument from Watt's behaviour.

it prudent to delay the publication until he should have considered it [the theory of the composition of water] more maturely, and have made some experiments to determine the proof or falsehood of it.'' This, it must be owned, was not the language of a man who had acquired that amount of conviction which is needful,—not to *broach* a theory,—but to hold fast by it against all opposition. With the caution which formed part of his character, Watt was unwilling to hazard his reputation by adhering to a doctrine which appears at the time to have received no support from his scientific friends, especially Dr Black. Having read the correspondence published by Mr Muirhead, I cannot doubt that Watt, whatever his private opinions might continue to be, would never have urged his views on an unwilling public, but would have finally suppressed the letter to Priestley, had not the experiments and claims of Cavendish at home, and of Lavoisier in France, reanimated all his zeal for the assertion of his opinion. This indeed Watt ingenuously admits in the letter to Sir Joseph Banks just cited, where he states that the fact of similar theories having since been supported by philosophers of first-rate abilities, removed his second objection to publication. As the suppression of his paper would have relieved Watt of all the responsibility of error, it seems impossible to allow him the advantage—of which that suppression deprived him—of anticipating the date of his matured conviction; and to this conviction we have his own evidence that Cavendish's publication as well as certain additional experiments of his own influentially contributed. Watt, in after life, may be said to have tacitly relinquished to Cavendish the honour which, in the first irritation of the conflict of their claims, he showed no disposition to do; it is, therefore, reasonable to infer that, on reflection, he saw good reasons for doing so. By this I mean that he suffered judgment to be passed in favour of Cavendish's claim in the writings of many of his eminent contemporaries, without attempting publicly to correct the all but universal impression which they made. In one instance, he almost homologated this adverse judgment:—In the article on Steam, written by Robison, and revised by Watt in his last years and after Cavendish's death, this passage appears,—"This is fully evinced by the great discovery of Mr Cavendish of the composition of water;"[1] from which it must be concluded, first, that Robison, the intimate friend of Watt, and the almost chivalrous defender of his fame, believed Cavendish to be the true discoverer;[2] secondly, that Watt, in commenting on this article in 1814, permitted the fact to be thus transmitted to posterity. For, in his numerous animadversions on other parts of the same papers, he gives (as I have pointed out in the note to art. 318) free expression to the sensitiveness which he felt lest Dr Black should derive any credit to which he was not entitled in connection with the steam-engine, but he suffers the passage just quoted to pass without remark. Such being the case, and waiving all purely chemical discussion, I am of opinion that Watt's friends should have left the matter as he was content to leave it.

(598.) Argument from the character of Cavendish.

With reference to the argument from Cavendish's character, I would remark that whilst the claim of Watt cannot be maintained without impeaching the honour and integrity of his rival, and showing that he stooped to subterfuge in order to appropriate to himself a discovery due to another—it would yet be difficult to find in the whole range of scientific history (without excepting the venerable name of Newton), an individual so devoted to knowledge for its own sake, so indifferent to the rewards of discovery, so averse to the publication of what he felt to be important, and knew to be original, so insensible to the voice of praise when applied to himself, so ardent in acquainting himself with the labours of others, and so liberal in assisting them. Such a man was Cavendish; and that he should stoop even to the common artifices of little minds for exalting his own reputation at the expense of others, would itself be incredible; how much more the insinuation (grounded solely on alleged circumstantial evidence) that in doing so he disregarded the plainest dictates of honour and justice.

(599.) Cavendish's experiments on latent and specific heat.

Black and Cavendish were nearly contemporaries, the former having been born only three years earlier. But I doubt whether these two men, so congenial in their studies, so different in almost every circumstance, whether of fortune or temperament, ever met. They had this, however, in common, that they published their discoveries and observations with reluctance, and were fastidious in the manner of doing so. Black's experiments, both in chemistry and on heat, preceded those of Cavendish, and with regard to the latter subject (heat) it is probable that Cavendish pursued investigations and made original experiments, in which he had been unknowingly anticipated by the Scotch professor. His researches on latent and specific heat (though he did not employ these terms) appear to have been subsequent to Black's, but to have preceded those of Crawford and Wilcke; and it is not impossible that his was the earliest, or one of the earliest, determinations of the amount of heat absorbed in the conversion of water into steam, for which he obtained various results between 923° and 982°, a mean of which would be very near the truth. But it is needless to dwell upon these observations, however original, because they were voluntarily suppressed by the author, and have only recently been brought to light from his manuscripts.[1] What he did publish in connection with this subject was a paper on the construction and graduation of meteorological instruments, especially thermometers, and others on the temperature at which mercury freezes, and on freezing mixtures. The former of these papers was, as might be expected, far in advance of its age in the degree of exactness which was shown to be attainable in the construction of thermometers, and scarcely even now can it be considered as obsolete. The papers on freezing mercury finally corrected the exaggerated notion at first entertained of the extreme cold at which that metal becomes solid, and also contain valuable views on the subject of congelation, and fixed the latent heat of water at 150°. He calls this, "generation of heat" during liquefaction, objecting to Black's term as relating "to an hypothesis, depending on the supposition that the heat of bodies is owing to their containing more or less of a substance, called the matter of heat; and as I think Sir Isaac Newton's opinion that heat consists in the internal motion of the particles of bodies much the most probable, I chose to use the expression, heat is generated."[2]

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[1] Robison's *Mechanical Philosophy*, ii., 21.

[2] The article WATER in the early editions of the *Encyclopædia Britannica* has been quoted as the production of Robison, of which there does not appear to exist any proof, whilst the probability, as shown in the text, lies all the other way. I learn upon the best authority that the proprietors of this *Encyclopædia* have no clue to the authorship of that article, and that it is not included in the lists of Robison's known contributions. The part relating to the present question was expunged in the Fourth Edition, and a reference made to the article Chemistry where Cavendish received the credit of the discovery.

(600.) Papers on the earth's attraction, and theory of electricity.

Two of Cavendish's most important researches refer to the attraction and density of the earth, and to the mathematical theory of electricity. The former (which, in principle, was derived from the Rev. John Michell) has been already analyzed in the chapter on Astronomy (art. 156). The latter will be more conveniently referred to in our chapter on Electricity.

(601.) Singular personal characteristics of Cavendish.

Cavendish's publications extended over the greater part of his active life, but those on chemistry and electricity, on which his fame principally depends, do not extend beyond the year 1775; the date of his paper on the density of the earth is 1798. He died 24th February 1810, at the age of 79. He appears to have exercised scarcely less influence by his general devotion to science, than by his specific discoveries, great and original as they were. In 1782, when Playfair met him incidentally in London, he described him as being generally looked up to as one possessed of talents confessedly superior, and as the only member of the Royal Society who then united the knowledge of mathematics, chemistry, and experimental philosophy. The absolute devotion of his life to inquiries the most abstractly scientific, whilst he showed an entire indifference to the luxuries which his wealth might have commanded, and the social station to which his birth entitled him, could not fail to inspire respect for his character, as well as to obtain the homage of mankind for pursuits so dignified and so generally disregarded. Many curious anecdotes are related of the annoyance which the inevitable accumulation of his unspent income occasioned. He no doubt would have distributed more liberally what he so little valued, but for the amount of time and inquiry which such a course must have compelled him to withdraw from his beloved pursuits. Some instances of his generosity are on record, and others, no doubt, will never come to light. M. Biot's epigrammatic description of him will probably long remain applicable,—"Il était le plus riche de tous les savans, et probablement aussi le plus savant de tous les riches."

(602.) This isolation of interest was doubtless due, quite as much to a constitutionally morbid temperament, as to a real misanthropy. He avoided even the most casual intercourse with his fellow men, excepting only when it was likely to bear the immediate fruit of scientific information. He almost never visited his relatives, and his heir paid him a visit of a few minutes once a year; but he frequented regularly the social meetings of the Royal Society Club, and the evening reunions of Sir Joseph Banks. But he came, not to participate, but to increase his stores; if he spoke, it seemed to be by inadvertence, and he was silenced by a question, or even by a look. "A sense of isolation from his brethren made him shrink from their society, and avoid their presence; but he did so as one conscious of an infirmity, not boasting of an excellence. He was like a deaf-mute sitting apart from a circle, whose looks and gestures show that they are uttering and listening to music and eloquence in producing or welcoming which he can be no sharer. . . . He was one of the unthanked benefactors of his race who was patiently teaching and serving mankind, whilst they were shrinking from his coldness, or mocking his peculiarities. . . . Such was he in life, a wonderful piece of intellectual clock-work, and as he lived by rule he died by it, predicting his death as if it had been the eclipse of some great luminary, . . . and counting the very moment when the shadow of the unseen world should enshroud him in its darkness."[3]

(603.) I shall only add, that Cavendish was elected one of the eight Associates of the French Institute in 1803. This is a distinction perhaps the highest, of a formal kind, to which a scientific man can aspire, and was given at a time when, as an Englishman, he must have felt it to be peculiarly honourable.

(604.) His philosophical character.

The philosophical character of Cavendish resembled in many respects that of Newton; and with but a slight modification of its secondary ingredients, he might have been, perhaps, another Newton in experimental physics. His singular incommunicativeness, and the absence of a laudable ambition to perpetuate his name by the establishment of great theories, are perhaps the main reasons why his reputation, except in chemistry, did not stand yet higher than we find it.

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[1] By the Rev. W. Vernon Harcourt in *British Association Report* for 1839. Compare Wilson's *Life of Cavendish*, p. 446.

[2] *Phil. Trans.* 1783.

[3] Wilson's *Life of Cavendish.*

A man indifferent to external relations pursues even his studies at a disadvantage; and the patient labours of so long a life devoted to a single object, would perhaps have told to greater effect had he published the results more frequently, and had he communicated more freely with those qualified to interchange their views with his. His excellent mathematical education, and his unusual skill in experiment, combined with a habit independent of either, but not less valuable, of patiently drawing inferences, might have placed him in the first rank as a discoverer in Heat, in Electricity, or in Optics,[1] each of which sciences was so soon to take a surprising step in advance. In several of his important researches, he was more or less anticipated; a circumstance which his cold nature would perhaps scarcely have allowed him to make an effort to prevent. Black preceded him in most of his excellent experiments on heat; Æpinus in his theory of Electricity; Watt was at least close on his traces in suspecting that water consists of oxygen and hydrogen; and the admirable experiment on gravitation had been devised by his friend Michell, and was not improbably recalled to his recollection, by the happy use of the torsion balance by Coulomb. It is given but to a few to achieve great discoveries, nor is the longest life always the most productive. Cavendish had his share, and some of the most considerable of these were even made later in life than is usual amongst experimentalists.[2] It is no mean eulogy of him to say, that the purity and ardour of his pursuit of truth were never exceeded, and that had he been more ambitious of praise, he might have stood as pre-eminent in mathematical physics as he did in chemistry.

(605.) Lavoisier. ANTOINE LAURENT LAVOISIER stands in intimate connection with Cavendish, as well by the nature of his pursuits generally, as by the brilliancy and importance of his chemical discoveries, which were nearly contemporaneous with those of Cavendish. He was born in 1745, and suffered by the guillotine on the 8th May 1794, without even the shadow of a misdemeanour. He was attached to the sciences of Heat and Chemistry, which he prosecuted with admirable success. He happily availed himself of the discoveries of Black, Priestley, and Cavendish, as well as his own, to establish the important chemical theory which has immortalized him. It is to be regretted that he was not always just in citing the English writers from whom he so freely borrowed. Such looseness was, however, common at that period, and (unfortunately) has continued to be so in France even to our own time.

(606.) His contributions to heat and chemistry. Lavoisier's more important papers may be classed under two heads; those referring more immediately to the subject of Heat as a branch of physics; and those of a more strictly chemical character, principally in support of the "Oxygen-Theory," and consequently also intimately connected with the doctrine of heat considered in reference to its most ordinary source, Combustion.

(607.) Papers on heat—calorimeter—specific heat. He published in 1772 a paper on the Latent Heat of Water, and some years afterwards one on the Latent Heat of Steam, which, in general, merely reproduce the views of Black. In the memoirs of the Academy of Sciences for 1780 (published 1784), we find an important paper on Heat written in conjunction with Laplace, in which the calorimeter is described, though not under that appellation, together with its applications and their results. The principle of the calorimeter is too well known to require to be detailed here; but the authors of the joint memoir refer, with commendable precision, to the previous labours of Wilcke of Sweden, who first employed the melting of snow to measure the quantities of heat given off by bodies in cooling. To Laplace and Lavoisier, is, however, due an important addition which could alone impart any value to the results,—that of the external chamber of ice which prevents fusion taking place by the contact of the external air and by radiation. The French philosophers were not so successful in eliminating the other source of inaccuracy specified by Wilcke, which arises from the difficulty of drawing off the whole of the melted water. Sir John Herschel has of late years proposed what seems to be an important improvement on the calorimeter, by filling the interstices of the snow or ice with water, and estimating the quantity of the former melted by the contraction of volume of the compound mass. I am not aware that it has been as yet practised. I have stated in Art. (88) one ground on which the idea of the calorimeter (so far as not anticipated by Wilcke), may be probably ascribed to Laplace. Another is to be found in the fact that, in the opening of the description of the method in the paper which we are considering, Laplace writes of himself in the first person.

(608.) Chemical theory of combination and oxidation. Of the memorable revolution which Lavoisier introduced into chemistry, more immediately in connection with the subject of combustion, I cannot be expected to speak here at length. It is well known that the early chemists entertained more correct views as to the calcination of metals than those prevalent during the greater part of the eighteenth century under the influence of Stahl's theory of Phlogiston; and that Lavoisier, in the first instance, only led chemists back into the right road by insisting that the increase of weight observed when metals are calcined in air, *must* be due to some ponderable substance associated with the metal and derived from the air, and not to the escape of an imaginary spirituous substance, endued with positive *levity*, and termed Phlogiston. But it required the progress which had already been made in pneumatic chemistry by Black and Priestley, and especially the discovery of oxygen by the latter (a fact sparingly alluded to by Lavoisier), to give to the true theory a stable foundation. That metals calcine, and that flames burn by the aid of the vivifying principle of the atmosphere abstracted from it, and which adds its weight to the compounds produced, was the primary step made by Lavoisier; to which, by cautious, yet rapid inductions, he added the knowledge of oxygen as the usual (he believed the sole) acidifying principle, and demonstrated the true nature of carbonic acid. To these various phenomena thus happily reconciled, he added the theory of respiration, confirming it by the effects observed in air which has undergone that process. These, and many other consequences of the "oxygen theory," were developed in a numerous series of admirable memoirs. The reception of it was anything but instantaneous; and the hesitation and delay which occurred, enable us, as Dr Whewell has well remarked, to estimate the force of mind which was required to promulgate the theory,—as the subsequent course of discovery, and its infinite applications in practice, best attest its importance.

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[1] This last subject seems to have been comparatively indifferent to him.

[2] His discovery of the composition of water was made when he was about fifty years of age.

(609.) His unfortunate death.

Lavoisier was still occupied in extending the conclusions of his chemical doctrines, when he was overtaken by the unprovoked sentence to a violent death. Like Archimedes, he begged a short respite for the completion of experiments in which he was immediately engaged, but he was silenced by the brutal reply that "the Republic had no need of philosophers." He left a name equal to any in the science of his time, and adorned by the memory of public and private virtues.

§ 3. DALTON.—*Theory of Gases and Vapours.—Law of Expansion by Heat.—Atomic Theory of Chemistry.*—GUY-LUSSAC.

(610.) Dalton—his early circumstances;

JOHN DALTON, the chief author of the theory of chemical equivalents or the Atomic Theory (as he preferred to call it), and of many important researches on the constitution of elastic fluids, was born at Eaglesfield, near Cockermouth in Cumberland, on the 5th of September 1766.[1] His parentage was humble, and his family belonged to the sect of Quakers, whose tenets he, to the close of his life, professed. Had we wished to invent a striking antithesis in the personal histories of the cultivators of science, or to illustrate merely the various soils on which rich crops of discovery may be reared, we could scarcely have imagined more striking contrasts than in the social positions and advantages of Black, Cavendish, and Dalton—three of the names which we have selected in illustration of the history of physics of their age.

contrasted with those of Cavendish and Black.

Cavendish we have seen connected with one of the noblest families in England, and wealthy almost beyond the dreams of the covetous; spending his life in or near London, and enjoying every facility of direct communication with the first scientific celebrities at home and abroad;—Black, almost the *beau ideal* of an Academic, not wealthy indeed, but surrounded by all the opportunities of study, of information, and of social intercourse which he desired; passionless almost to a fault; admired by his pupils and friends; enjoying, in short, all the advantages which education and a literary position can afford for the prosecution of a favourite study;—Dalton, on the other hand, poor and hardly winning a well-earned subsistence by private tuition, from the time he was himself a child until near the close of his long career,—with few friends, a scanty education, and a scantier library,—attaining, through his unaided and long almost unheeded efforts, and by means of an apparatus constructed entirely by himself, a position in the world of science unquestionably not second to that of either of his more highly-favoured contemporaries.

(611.) At the age of thirteen he had commenced the arduous office of an instructor; and from 1781 to 1792 pursued the same occupation in a humble sphere at Kendal, where he fortunately became acquainted with Mr Gough, a blind gentleman of some fortune, who devoted his time to the prosecution of science in nearly all its branches, and particularly of mathematical subjects, of which he has left an enduring record in many ingenious papers, published chiefly in the *Manchester Transactions* and in *Nicholson's Journal*. He patronized young Dalton, giving him free access to his library and apparatus, and receiving from him in return the benefit of his assistance in prosecuting his experiments. Dalton always recognised (as he had unquestionably good reason to do) the merits of his patron, and the importance of the advantages which he had derived from his advice and example. Indeed, without some such fortunate concurrence of circumstances (and something similar may be noted in the history of nearly all self-educated men), it could hardly have been hoped that Dalton would have been so well grounded in the mathematical principles of at least some branches of Natural Philosophy as he probably was. For, though his discoveries bear mainly on the science of chemistry in the wide sense in which it was then understood, yet geometrical precision is after all their fundamental characteristic; and whether in treating of the constitution of a gas, or of the scale of a thermometer, or of the composition of a salt, it is evident that numbers and ratios were the ideas predominating in his mind. In this he resembled Cavendish; but he did not resemble him, and in one sense may be said to have surpassed him, in the boldness, we might call it audacity, with which on a frequently too slender foundation of facts Dalton established, to his own satisfaction, by reasoning almost as much *à priori* as that of the mathematician, comprehensive physical theorems expressing the laws of phenomena.

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[1] *Life of Dalton*, by Dr Henry, in the publications of the Cavendish Society. The present section was originally written before the appearance of this biography.

(612.) Dalton's writings. The more important of these refer to the constitution of gases and vapours, together with their relations to heat, and to the combinations of bodies by chemical affinity. We shall endeavour to give some account of these researches separately. They are to be found detailed in the *Memoirs of the Literary and Philosophical Society of Manchester* (particularly the fifth volume), and in Dalton's *New System of Chemical Philosophy*, of which three successive parts appeared in 1808, 1810, and 1827, of which the first is the most original and important.

(613.) Researches on gases and vapours. I. We shall first speak of his researches connected with gases and vapours. It had been noticed by Priestley and others that when gases exercising apparently no chemical action upon one another, are mixed in a confined space, they become, after the lapse of a longer or shorter time, completely intermingled, and *that* without any regard to even great differences in their density, the particles of the lighter gas diffusing themselves contrary to gravity through those of the denser, and causing them in their turn to ascend. The uniform composition of our atmosphere, in all circumstances and at all heights, is a striking example of this property. In explanation of it, Dalton had in 1801 arrived at the conclusion, "that the particles of one gas are not elastic or repulsive in regard to the particles of another gas, but only to the particles of their own kind." The fundamental experiment on which this singular conclusion was based was the following:—That the quantity of vapour of water (which, when purely elastic, may be considered as a gas) which can exist uncondensed in a given space, depends *solely* upon the temperature, and is independent of the presence of air and of its own density. Thus water, or any other evaporable liquid, being introduced into a space containing air, or any other gas, of any density, but subject to a constant external pressure, the space in question becomes damp by the evaporation of the liquid; now the amount of the latter converted into vapour depends, according to Dalton, upon the single circumstance that the vapour yielded by it must have the precise elasticity due to its temperature. Its elastic force being added to that of the dry air, the whole will expand until equilibrium is restored with the constant pressure without, and this will occur as soon as the elasticity of the dry air alone (proper to its increased volume), added to the elasticity of the vapour alone (depending solely on its temperature), are together equal to the pressure which they have to support. In short, to use the precise enunciation of Dalton himself, "in all cases the vapour rises to a certain force, according to temperature, and the air adjusts the equilibrium by expanding or contracting as may be required."[1]

(614.) Theory of hygrometry. The importance of this law (easily verified in the particular case) is readily perceived. Not only did it affect the results of almost every experiment in pneumatic chemistry, but it rendered a new theory of hygrometry indispensable. The older theory of Halley, Leroy, and Franklin was, that the direct affinity between air and water drew up a portion of the latter into the former with the aid of heat, whilst De Saussure (*Essai sur l'Hygrométrie*, 1783) believed that the conversion of water into vapour took place first and independently by the action of heat, and that it was then drawn up into the atmosphere by the attraction of the gases which compose it. Dalton's experiments show that the air and the vapour mix without the slightest mutual interference or reaction. He founded thereupon an excellent practical method of determining the amount of vapour in the atmosphere. He first formed a table of the elasticities of watery vapour or steam for all temperatures between 32° and 212°; and so simple and accurate were his methods, at least for the lower degrees of the thermometer, that his numbers are still received as amongst the best we have. He operated merely with a carefully constructed barometer, into the vacuum of which he introduced a few drops of water, and raising the temperature by means of a tube embracing it, and which could be filled with water at pleasure, he observed carefully the depression of the mercurial column. The elasticities thus determined commenced with 0·2 inches of mercury at 32° up to 30 inches at 212°. These numbers, consequently, represent the *utmost* elasticities of vapour which can exist either *in* air or *without* air at the corresponding temperature. If we attempt to add more vapour, or to lower the temperature, in either case moisture will be deposited. Dew-point experiment. Hence to find the quantity of vapour in the atmosphere when not absolutely damp, it is sufficient to ascertain the temperature at which it becomes so. This Dalton did by filling a thin glass with cold spring water, or by adding, if necessary, the solid nitrate of ammonia, until the temperature fell so far that dew began to be deposited on the surface. This excellent method constitutes in fact the *dew-point hygrometer.* It has received various forms from Mr Daniell and others, but the original one is probably the best.

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[1] The exact expression of the effect is this, $v = \frac{p}{p-f}$, where p represents the pressure expressed in inches of mercury upon a given volume (equal to *unity*) of dry air; f the force of the vapour in vacuo at the temperature of experiment, also in inches of mercury; and v the volume which the mixture of air and vapour occupies under the given pressure p after saturation. It is evident that $p-f$ being the pressure due to the elasticity of the dry air apart from the vapour, when we affirm that the volume (1) becomes $\frac{p}{p-f}$, we in effect affirm that Mariotte's (or Boyle's) law connecting volume and pressure holds true for air which is mixed with vapour, just as though vapour were absent or its space void.

(615.) Laws of mixed gases.

These important laws and deductions being fully understood, the theory of the mixed dry gases follows as a simple corollary. For it merely asserts of them what has been admitted in the case of steam, that they may diffuse themselves, and exert their elastic forces quite independently of one another; so that, for example, in our atmosphere the total pressure is made up of the partial elasticities of the oxygen, nitrogen, and carbonic acid which compose it, each acting to the same amount as if it alone had existed in the space which it occupies. In his essay of 1801, Dalton stated his view of these facts thus:—"The particles of one elastic fluid may possess no repulsion or attractive power, or be perfectly inelastic with regard to the particles of another."

(616.) Dalton's mechanical ideas on the subject.

Discoveries so practical could not fail to excite immediate attention, especially at a time when the researches of chemists were earnestly directed towards the gases. "The facts and experiments," Dalton tells us in his *Chemical Philosophy*, "were highly valued; some of the latter were repeated and found correct, and none of the results controverted; but the theory was almost universally misunderstood." Its opponents were Berthollet, Thomson, Henry, and others, and the replies of the author are contained in the work just cited. But he appears to have felt the force of the objection, "Can it be conceived that an elastic substance exists which adds its volume to that of another, and which, nevertheless, does not act on it by its expansive force?"—for in his chemical philosophy he abandons the comparison of gaseous particles to similar magnetic poles which repel each other, but are inert towards non-magnetic matter, and allowing that heat is the primary cause of repulsion in all gases, ascribes their diffusion contrary to gravity to the dissimilar size of their spherical molecules. "The particles of one kind being from their size unable to apply properly to the other, no equilibrium can ever take place amongst the heterogeneous molecules. The intestine motion," he adds, "must therefore continue till the particles arrive at the opposite surface of the vessel against any point of which they can rest with stability, and the equlibrium at length is acquired, when each gas is uniformly diffused through the other." It may be seriously doubted whether this theory of the facts will bear examination, at least no attempt has been made to demonstrate it on mechanical principles. The subject has been allowed to remain during more than forty years of unequalled activity in such speculations without material light being thrown upon the proximate causes of these wonderfully general and simple truths. Yet it can hardly be doubted that the mechanical theory of the gases and vapours is capable of a great extension, and even of being illustrated by simple experiments. But the attention of chemists has been withdrawn from the physical bearings of their science by the prodigious increase in the number of compounds which they have had to analyze and classify. The most important sequel to Dalton's discoveries has probably been that of Professor Graham, whose experiments prove that gases when separated by a porous partition permeate it in both directions, until they have mixed in proportions which are inversely as the square root of their density. This law clearly shows the purely mechanical causes by which the diffusion is effected.

Mr Graham's law of diffusion.

(617.) Dalton on the expansion of the gases by heat.

A discovery of Dalton, which has scarcely been considered second in importance to those we have mentioned, is that *the rate of expansion of all gases by heat is the same.* Thus thermometers of air, hydrogen, and carbonic acid would all mark the same degree when plunged in the same medium; whilst the mercurial thermometer shows a more rapid expansion, at higher temperatures, if the air thermometer be taken as the standard. This important fact was soon after but independently announced by Gay-Lussac of Paris. Dalton's publication dates from 1801. In his Chemical Philosophy, he gives his view of the difficult subject of a true thermometric scale; which he does not suppose to be correctly represented by the simple expansion of any known substance; but that the gases expand with true increments of heat in a very slow geometrical progression, whilst liquids expand as the squares of the true temperatures from their freezing points. These and other laws equally arbitrary have not received support from later and more precise experiments; and in the second volume of his work (1827) he freely acknowledges the correction of his hypothesis by the more recent French experiments.

(618.) Dalton's Atomic Theory.

II. I now proceed to the other part of Dalton's labours on which his reputation is principally based; namely, the clear assertion and experimental establishment of the Atomic Theory or doctrine of chemical equivalents. I introduce it here on account of its important bearing on all physical questions in which the constitution of matter and the forces acting at minute distances are involved.

(619.) Early opinions on the constitution of matter.

Early opinions on the constitution of matter and chemical combination.—Two opinions have prevailed from the very earliest times respecting the constitution of body:—that which supposes its entire homogeneousness, and that which allows that it consists of material parts or atoms separated by void spaces; these parts or atoms being indivisible. This last is the doctrine of Democritus and Epicurus, and in modern times of Bacon, Newton, and Dalton.[1] The former opinion has been held by Leibnitz, and many writers of the recent German school. Abstracting as far as possible from the more purely metaphysical difficulties (such as those which the consideration of Leibnitz's law of continuity introduces), we may perhaps be justified in stating that, whilst the objections urged against the existence of atoms fall upon our inability to conceive and describe the properties of these individual ultimate parts in a consistent manner,—the objections to the other notion meet us at an earlier stage, and seem to defy any clear conception of the nature or possible existence of compound bodies, or of bodies in two states of consistence. Admitting atoms—whilst acknowledging our inability to describe them individually—we can clearly enough conceive the phenomena of condensation, rarefaction, evaporation, &c., and also of the combination of elements in compounds possessing distinct properties; but excluding them, or allowing that matter is penetrable by matter throughout, is it possible to conceive clearly of such a compound,—as for example, of the perfect diffusion of two gases in the same space, yet each gas retaining its individuality so completely as to admit of easy and complete separation from the other? The theory of Boscovich, which has been sufficiently touched upon by Sir John Leslie in the previous Dissertation, was intended, no doubt, to reconcile the two opposing theories, and it cannot be doubted that it is in many respects an ingenious solution. Yet it is essentially (as Professor Robison maintains) a corpuscular or atomic doctrine, and it farther appears to be difficultly reconcilable to the doctrine of inertia; for how can a finite number of unextended physical points, though they may be the centres of intense *forces*, constitute a finite aggregate *mass?* Nevertheless this speculation has been on the whole favourably received, and in our own time seems to have been adopted by so eminently practical a philosopher as Dr Faraday.

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[1] The reader will find ample details on the opinions of the older philosophers in Daubeny's *Introduction to the Atomic Theory,*

Boscovich.

(620.) Dalton's views on the subject.

About Dalton's idea of atoms, however, there can be no doubt. They are, according to his view, ponderable, indivisible masses, having length, breadth, and thickness, consequently form. He had distinct conceptions of their relative weights, distances, and specific heats. He was particularly fond of depicting them in diagrams, to which he often refers for a clearer exposition of his views than he chose to give in words. A mechanical mixture of gases like the atmosphere is for him a uniform diffusion of the atoms of each gas throughout the space occupied by the whole, and without reference to the position of the atoms of any of the others. But a chemical compound consists of molecules or complex atoms, each composed of two or more ultimate particles of the constituents firmly united by a chemical force, and these complex molecules act towards one another exactly as simple ones might do. The general notion of chemical forces or *affinities* (as they were perhaps first called by Geoffroy, a French chemist) appears to have been apprehended in two different senses corresponding to the atomic or non-atomic theory of body. For the former proceeds on the assumption of direct attractions or repulsions (*push-and-pull* forces, as they have been called) uniting some and tending to separate others, thus assimilating completely chemical with mechanical forces. The other school adopts the word *affinity* as expressing a mode of action of matter upon matter totally distinct from that of force producing motion in its particles, to which it is difficult to give an intelligible form, much more to prove that the assumption is warranted by the facts.[1] In this state of matters the choice between an opinion perhaps erroneous, and one which assumes no definite shape, can hardly, to the practical philosopher, remain long doubtful; when new facts shall have enabled him to express intelligibly a new hypothesis, it will be time enough to adopt it.

(621.) Dalton's laws of chemical combination.

Dalton's Atomic Theory.—I shall first briefly state the general facts or laws to which Dalton gave an universal application, and then briefly refer to the undoubted anticipation of part of them by earlier chemists. For the sake of distinctness the *facts* of the atomic theory may be thus enumerated:—1. That when two bodies unite, not merely by mechanical mixture but through a chemical affinity of the elements,—two or more ingredients forming a whole with new properties,—these ingredients are invariably found to exist in *constant proportions.* For instance, the carbonate of lime invariably consists of 44 parts by weight of carbonic acid and 56 of lime, the slightest addition of either element remaining uncombined, or only mechanically mixed with the chemical product. 2. In many instances, however, more than one chemical combination can be formed between two or more elements, and in the simplest cases, where the elements are two in number and one remains constant in quantity whilst the other increases in amount, a fresh chemical union of the particles does not occur until one of the ingredients reaches precisely double the amount

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and in Whewell's *Philos. of Inductive Sciences*, vol. i. Newton's conjecture is expressed in these words:—"All things considered, it seems probable that God, in the beginning, formed matter in solid, massy, hard, impenetrable, moveable particles, of such sizes, figures, and with such other properties, and in such proportion to space, as most conduced to the end for which he formed them. And that these primitive particles being solids, are incomparably harder than any bodies compounded of them; even so very hard as never to wear or break to pieces; no ordinary power being able to divide what God himself made one in the first creation." Horsley's *Newton*, vol. iv., 260, quoted by Daubeny.

[1] A profound and subtle thinker of our own time (Mr Leslie Ellis, of Trinity College, Cambridge) has made a definite suggestion as to a possible form of chemical forces, viz., that they may not be such as are directly exerted between a particle A and a particle B, but only by their presence enable A to act on B, or bear the same relation to force (common force) as force in mechanics does to the motion which it causes. Thus, the science of mechanics would include—1st, Kinematics, or pure motion depending on equations of the first order; 2d, Dynamics, depending on equations of the second order; 3d, Chemical, Vital, &c., forces, depending on equations of higher orders. *Camb. Trans.*, viii., 604, &c.

which had chemically combined with the other; and if it happen that fresh compounds are formed possessing new qualities, then the varying ingredient reaches 3, 4, or 5 times the amount which it had in the first combination; or more generally the proportions by weight of the combining elements may be *exactly* represented by whole numbers. 3. "If two bodies combine in certain proportions with a third, they combine in the very same proportions with each other." This is called the law of *reciprocal proportion*. Thus, suppose that one ounce of a body A, saturates or forms a chemical combination with two ounces of B, 5 of C, and 11 of D; then if B, C, and D are capable of combining, it will be in the exact proportions of the numbers 2, 5, and 11. Hence a single number being determined for each body, determines all its possible combinations with other known bodies. 4. It may perhaps be added as an independent fact, that when complex bodies combine with other bodies, no matter whether simple or compound, the combining number of the complex body is the sum of the numbers representing the constituents. Thus the combining number of lime is 28; but lime consists of calcium 20 and oxygen 8. So also the combining number of water is 9; but water consists of hydrogen 1 and oxygen 8: and the combining number of hydrate of lime is 37, the sum of the 28 parts of lime and 9 of water of which it is composed.

(622.) Partial anticipation of some of these laws.

The discovery of these laws has been termed by Sir John Herschel the most important, after the laws of mechanics, which the study of nature has yet disclosed. No slight or transient reputation is due to him who first clearly apprehended and taught them. Nor must we be surprised to find several claimants to a share of the honour. It is the invariable history of all great generalizations, that they have been partly anticipated; and it may serve to moderate the self-esteem of even the greatest discoverers, that however high may be their individual merits, they are in some sense the mere exponents of the aggregate knowledge of their contemporaries. The laws of motion were partially anticipated before the time of Galileo, and could not have remained much longer undefined; and even the unparalleled discoveries of Newton must, in all probability, have ere long been made piecemeal by the united energy of his contemporaries and immediate successors. The steam-engine was not the sole creation of Watt, nor was Davy the first to apply the voltaic battery to chemistry. In like manner, Dalton's laws of chemical combination were published at a happy moment, which gave them speedy acceptance with the active chemists of his day; whilst those who had seen with sufficient clearness portions of these laws twenty or thirty years before, addressed a scientific public by no means prepared to appreciate their value, or to feel a conviction of their generality. Had Wenzel,[1] Higgins,[2] and Richter[3] individually apprehended the great importance of the definite and multiple combining proportions which they announced,—had they felt the theory of them to constitute the very foundations of chemistry,—they would not have rested until they had verified it in numerous details, and applied it to the various purposes of speculation and practice, as Dalton did. But whether from want of energy, or from ill fortune, their ideas sunk into entire oblivion; and the ingenuity and social position of Berthollet were giving a currency to opinions respecting chemical forces which tended to undo even the far more elementary notions of the constancy of elective affinities, at the time when Dalton's researches were unostentatiously brought before the world. His first insight into the theory of chemical combinations dates from the year 1803. It was expounded by him both in conversation and by lectures in 1804, at which date Dr Thomas Thomson recorded the results of a conversation held with him at Manchester, which, three years later (evidently with Dalton's approbation), he published in his work on Chemistry. Finally, Dalton himself, in 1808, announced the principles of his theory at no greater length than five pages "on Chemical Synthesis" in his *Chemical Philosophy*.

Wenzel, Higgins, and Richter.

(623.) Importance of the Atomic Theory to the progress of chemistry.

Now, it is to be observed, that Dalton's views were all along expressed in the language of a strictly *Atomic* theory. Compounds are only chemically complete, when one or several atoms of an element combine with one, two, or more atoms of another. Any superfluity of either element remains uncombined, or mechanically mixed. All the other parts of the laws of combination readily lead to the same idea, and, in fact, find in it their simplest expression. There is no wonder, then, that Dalton firmly believed in the physical existence of his atoms, and that the new properties of compounds are due to the peculiar modification of the most elementary parts into which bodies can be divided without a loss of those properties, that is, without decomposition. He figured these elementary molecules by uniting the symbols of their constituents, and by so doing, may be said to have laid the foundation of those algebraic systems of technical notation, which speak to the eye only in another way from Dalton's diagrams, and which have been of such eminent service to the chemist. Nor must we think too lightly of a hypothesis which served so materially to aid in realizing a discovery of such magnitude. Dalton's earlier researches were far more physical than chemical; and it is evident that the effort of representing to his mind, geometrically and atomically, the condition of mixed gases and vapours, led him to form clear ideas on the definiteness of chemical combinations. The delay in publishing his views, no doubt depended on his desire to present them to the public in the form of a somewhat wide induction, although it is certain that his own opinion was fully formed from a knowledge of only one or two cases of multiple proportions, and especially the combinations of hydrogen and carbon. It cannot be fairly urged as conclusive against the theory of atoms, that cases occur difficult to reconcile with the author's formal statement of it. There is no great theory—not even that of gravitation itself—which has not met with similar apparent contradictions.

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[1] *Lehre von der Verwandschaft der Körper*, 1777. He shows that in a double decomposition the new compounds are chemically perfect.

[2] *A Comparative View of the Phlogistic and Antiphlogistic Theories*, 1789, by Mr William Higgins, points out the multiple combining proportions of sulphur and oxygen, and of nitrogen and oxygen, but only incidentally. Dr Bryan Higgins, a relative of Mr W. H., had published, in 1786, a work said to contain the idea of definite atomic combinations.

[3] *Anfangsgründe der Stöchyometrie*, 1792. He gave a series of numbers representing the combining proportions of different elements.

(624.) Its reception in England,

The reception of the views of Dalton was somewhat gradual, yet might be called rapid, considering the obscurity of the author, and his provincial residence. The energy of Dr Thomson of Glasgow contributed more than any other circumstance to compel the attention of chemists. He personally brought it under the notice of Wollaston and Davy; and the former, who, by his habits of precise thought and accurate experiment, as well as from his extensive chemical knowledge, would of all others have been the most likely to see its importance and probability, was doubly predisposed in its favour by having been himself for some time in possession of facts illustrating the numerical laws of combination similar to those which Dalton possessed. Wollaston published these in the *Philosophical Transactions* for 1808, in which he expressly states, that Dalton had anticipated him in the results of his enquiry into multiple combinations of elements. Davy, as might have been expected, was less prepared to accept a doctrine having the form of a mathematical law; he did so, however, after a short resistance. In his *Chemical Philosophy* he ascribes most if not all the merit of it to Higgins, and is supposed to have looked coldly upon Dalton's growing fame; but it is gratifying to add, that in almost his last appearance in public as president of the Royal Society, when presenting Dalton with the first royal medal, he should have expressed himself in terms of cordial praise.

(625.) and France. Gay-Lussac's law of volumes.

In France the new doctrine soon spread, notwithstanding its violent contradiction to the theories of Berthollet. Gay-Lussac was amongst its earliest and most enlightened advocates; and he had the good fortune to add, in 1809, a new law to the principles of chemical combination, which is, that the gases, in uniting chemically, combine in equal or multiple *volumes*, and when any condensation occurs after they have united, it amounts to an exact fraction ($\frac{1}{2}$ or $\frac{1}{3}$) of their joint bulk. This was the only addition made for a very long period to Dalton's laws, even if we consider the theory of Isomorphism and of Substitutions to take the same rank; and as it evidently includes the idea that the atomic weights of the gases have a simple numerical relation to their densities, it confirms Dalton's views of the great simplicity and uniformity of constitution of those bodies. In Sweden the doctrine of definite proportions found one of its earliest advocates in Berzelius, and his analyses contributed perhaps more than those of any other chemist to its perfect establishment.

(626.) "Chemical equivalents."

It is not to be concluded, however, that the atomic or theoretical part of Dalton's laws obtained the same currency with the conditions of chemical combination which they serve to define. Wollaston and Prout were perhaps the most favourably disposed to the doctrine of atoms, though the former invented the term "chemical equivalents" to escape from the theoretic inference, and the latter believed that Dalton's law was only a portion of a more complicated one regulating chemical combinations. Wollaston even sought evidence in favour of ultimate atoms, from considerations of a purely mechanical kind, such as the existence of a limit to the atmosphere (*Phil. Trans.* 1822). We may however admit, with those who have taken an opposite view, that the finite extent of the atmosphere is consistent with a continuous mathematical law suitably assumed, and without reference to atoms at all; if, indeed, we can imagine a medium varying enormously in density, yet possessing perfect continuity of body. But we will not enlarge farther on these almost metaphysical considerations.

(627.) Dalton's personal history continued.

During the period from his settlement in Manchester in 1793, to the publication of his *Chemical Philosophy* in 1808, Dalton was occupied in tuition, first in the Mosley Street Institution, where he lectured on mathematics and natural philosophy for six years, and afterwards, privately, in a very humble and unpretending manner. His speculations and experiments gradually became more and more strictly chemical; and, aware that his atomic theory was to be the great foundation of his fame, he spared no pains in illustrating it by numerous analyses. Contemporary chemists have testified to the ingenuity and fidelity of these. Yet, isolated as he was, and unacquainted perhaps with those niceties of manipulation which are suggested by the experience of professional chemists, and rapidly communicated in great cities, his numerical conclusions were often inexact. Probably he felt some discouragement from this, at well as from the indifferent reception of the later parts of his *Chemical Philosophy*, in which he had to admit the inaccuracy of his theoretical scales of heat and expansion. At all events, his publications became more scanty and less original, though he was still near the meridian of life. The reality of his discoveries had been somewhat coldly acknowledged, and he felt little temptation to adventure himself in a more bustling arena, for which his habits and circumstances seemed to unfit him. Nevertheless, he had been, as early as 1816, elected a corresponding member of the Institute of France—Wollaston being then probably the only other English name on the list.[1] Dalton found his way to Paris in 1822, and was agreeably surprised by the distinction with which he was received by the most eminent members of the Academy of Sciences. Perhaps this first *personal* recognition of his exalted station, as a man of science, had something to do with the tardy adjudication to him four years later of one of the medals of the Royal Society of London. In 1830 he was elected one of the eight associates of the Academy of Sciences in the room of Sir Humphry Davy.

(628.) His character

In 1833, at the age of sixty-seven, he received a pension from government, up to which time he had maintained himself in the way already mentioned, with the utmost simplicity and contentment. Even in his lifetime it was impossible for his eulogists to forbear from some reference to this essential part of his really philosophic character. "Mr Dalton has been labouring," says Sir Humphry Davy, "for more than a quarter of a century with the most disinterested views. With the greatest modesty and simplicity of character, he has remained in the obscurity of the country, neither asking for approbation, nor offering himself as an object of applause." "There is little doubt," says Dr Thomson, "that Mr Dalton, had he so chosen it, might, in point of pecuniary circumstances, have exhibited a much more brilliant figure. But he has displayed a much more noble mind by the career which he has chosen; equally regardless of riches as the most celebrated sages of antiquity, and as much respected and beloved by his friends, even in the rich commercial town of Manchester, as if he were one of the greatest and most influential men in the country." All who had the good fortune to know him personally—to see him, as the writer of these pages has done, in his modest school-room, and surrounded by his unpretending apparatus—will own that these eulogies are not overdrawn. His latter days were spent in cheerfulness and comfort; he expired on 27th July 1844, having nearly completed his seventy-eighth year.

and death.

(629.) Dalton's philosophical character.

The philosophical character of Dalton may be briefly summed up. He had immense vigour of conception, and an ardent love of truth. He was thoroughly devoted to the pursuit of science during his long career, and he evidently sought and expected no higher reward than the insight which he obtained into the laws of nature. His mind, like his frame, was of a strongly masculine character, and happily exempt from nervous sensibility and other like infirmities of genius. Whilst he held his own opinions with tenacity, and criticised freely those of his opponents, there is not a trace of acrimony in any of his writings; and he always spoke in terms of high respect both of those who pursued science in a similar direction with himself, and (what was more difficult) likewise of those who, having the good fortune to hold more conspicuous positions, showed him the smallest degree of kindness, which he always gratefully acknowledged. He was unlike Black and Cavendish, in the rapidity with which he seized on a few isolated facts, and made them the basis of an inference of great generality; this, indeed, was his leading characteristic; and he differed from them equally in the boldness with which he claimed from the public a general acceptance of his conclusions. Some of his inferences were unguarded enough, and have not been confirmed; and the reception of what were correct was naturally delayed by the evident facility with which his theories were shaped in his own mind. Most of his papers appeared in rapid succession; only the Atomic Theory was brought with some evident hesitation before the world. In all this we see the results of a vigorous imagination, united with great perseverance, in working out an idea. The imaginative element would have been more under control had his education been of a less irregular kind. We see the effect of an opposite turn in his eminent predecessors just named. They would have done more, had they trusted more. Dalton's discoveries may be said to have terminated at the age of forty. Though he laboured for thirty years after, the conceptive faculty seems to have spent itself in its earlier efforts.

(630.) Gay-Lussac—chemist and physicist.

Joseph Louis Gay-Lussac, an eminent French chemist and physicist, contemporary with Dalton, has been mentioned in the course of the present section, as having discovered independently the equal dilatation of the gases, and also a law of their combinations in connection with their volumes, which was peculiar to himself. Besides these researches, science owes many useful observations in physics to his energy and talent, which, in the origin of his career, promised more of originality than his maturer life perfectly fulfilled. He was born in the old province of Limousin in 1778, and became the pupil of Berthollet in chemical researches, and was one of the earliest and most active members of the Société d'Arceuil. In physics, he was the collaborator of MM. Biot, Humboldt, and Laplace. With the first of these philosophers he made his earliest experiment in aërostation, which he repeated alone on the 16th September 1804, when he attained the amazing height of 7016 mètres (23,019 English feet), an elevation previously unattained, and which in the course of the succeeding half century has only twice been touched, or exceeded by a small quantity.[2] Con-

Remarkable balloon ascent.

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[1] So stated by Dalton himself (*Life* by Dr Henry, p. 163); but I suspect some misapprehension. Considering the importance attached to these nominations, it is to be regretted that it is at all times difficult to ascertain who are, or have been, associates and correspondents of the Academy of Sciences.

[2] Once by MM. Bixio and Barral in 1850, and once by Mr John Welsh in 1852.

sidering the novelty of the experiment in 1804 (only twenty-one years after Montgolfier's first successful experiment), this fact speaks strongly for his courage and zeal. These ascents were also the first undertaken with strictly scientific aims, and the observations made were highly interesting in connection with the decrement of temperature in the atmosphere, with the uniformity of composition of air at all heights, and with the question of whether the magnetic force of the earth diminishes at such elevations. This last enquiry was not conclusively answered.

(631.) With M. de Humboldt he made observations on terrestrial magnetism in Italy, and on other subjects. Miscellaneous experiments of Guy-Lussac. By desire of Laplace he studied the facts of capillary attraction. In more immediate connection with the subject of the present chapter, he made some valuable experiments on hygrometry, on the mechanical properties of vapour of different kinds, and on the specific heat of the gases. His fame, however, mainly rests on the two investigations to which we previously referred, and on the results of his balloon journey. His later years were devoted to practical enquiries connected with chemistry, and to his official duties at the Mint. He died at Paris on the 9th May 1850. His death.

§ 4. Rumford.—*Economical applications of Heat.—Point of Maximum Density of Water;* Hope. —*Friction as a source of Heat. Theory that Heat is convertible into Mechanical Energy;* Mr Joule.

(632.) Thomson, Count of Rumford. The name of Thomson, Count of Rumford, deserves a passing notice in the history of the physical sciences, if not for the absolute importance of his discoveries, at least as an instance of a class of benefactors to mankind at once in a physical and intellectual point of view. He was altogether in advance of his age in the application of correct theory to the improvement of the social condition of the lowest classes; and many of his experiments, and, indeed, discoveries, seem now at once so simple and so familiar, that we are apt to forget how entirely original they were sixty years since.

(633.) His early history and studies. Sir Benjamin Thomson, an American by birth, a British knight, and a Bavarian or rather Austrian count, was born in the United States in 1753, and passed his earlier years almost entirely at military stations during the American war, being engaged on the British side. After the establishment of independence, he quitted his country for ever; came first to England, where he was well received, and proposing to enter the Austrian service, he proceeded as far as Munich, where, having become known to the elector of Bavaria, he was induced to settle; and having received different civil and military appointments, he devoted himself for a series of years to the improvement of the social condition of that capital. He introduced great improvements into the management of the army; the mechanical and chemical departments of the artillery had a peculiar charm for him; they were conducted on strictly scientific principles, and, in return, were made to contribute important results to science. His experiments on the heat of friction, deduced from the boring of cannon, are amongst the best we possess; and they led him to results of considerable theoretical importance to which I shall presently refer.

(634.) Enquiries into the economical applications of heat. But his most serviceable efforts on behalf of mankind were in the treatment of the mendicant classes with which Munich then swarmed. Salutary views of the importance of industry, order, morality, and public economy, were most happily united to a happy versatility of talent in physical research, to unwearied patience and great liberality, in effecting one of the greatest social reforms on record. The strict statistics of a great house of industry were ascertained with reference to the most seemingly insignificant details, and, in particular, all the applications of Heat to the physical wants of mankind were studied with equal assiduity and success. The warmth of clothing was traced to the amount of still air entangled amongst its fibres,—the dissipation of heat, whether from a thermometer or a kitchen boiler, was classified under radiation, conduction, and convection, the last and often most important of which (signifying the influence of currents in liquids and gases in conveying heat by the changing density of their parts) had hardly before been recognised, or at least made the subject of formal experiment,—the effective heat due to the combustion of different kinds of fuel, tested by a calorimeter of his own invention, —the economy of light based on an investigation of the properties of flame;—these were but a few of the trains of enquiry, of which his Mendicity House was the primary object. Charity and science went Practical benefits resulting. hand in hand; and when we award to Watt the highest honours for an invention which enabled him to create mechanical force at an economy of two-thirds of the coal previously consumed, shall we deny Rumford a civic crown for having so improved the methods of heating apartments and of cooking food, as to produce a saving in the precious element of heat, varying from one-half to *seven-eighths* of the fuel previously consumed?[1] When we consider the enormous price of wood in nearly every part of the Continent, the destruction of forests which has occurred, and the consequent injury to the climate, as well as to the material wealth of many districts, we are disposed to give Rumford a higher place than has generally been accorded to him. Had his excellent principles been universally carried out, some millions sterling would have been saved to every large state in Europe. Fontenelle characteristically says of a certain *savant*, who made experiments on nutrition, with a view to carry fasting to the utmost practicable extent, that his researches had the double aim of a place in heaven and in the academy. Cuvier, who tells the anecdote in his *Eloge* of Rumford, adds, that the latter had a truer claim to the questionable compliment. That science is surely not despicable by which a pound of wool, of fuel, or of food, can be made to go one-half farther than before in warming the naked and in feeding the hungry.

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[1] In the hospital of Verona he reduced the consumption of wood to *one-eighth*. Some one wittily said of Rumford, that he would not rest until he had cooked his dinner with his neighbour's smoke.

(635.) Different experiments.

All Rumford's experiments were made with admirable precision, and recorded with elaborate fidelity, and in the plainest language. Everything with him was reduced to weight and measure, and no pains were spared to attain the best results. His experiments on heat, and the properties of bodies in connection with it, are the most important. He first applied steam generally in warming fluids and to the culinary art. He maintained the paradox of the non-conducting power of liquids, which, though practically true, appears not to be rigorously so. He contrived many ingenious instruments; but his thermoscope, identical with Leslie's differential thermometer, was probably of later invention, if not in some measure borrowed from it. In like manner his proofs of the maximum density point of water were unquestionably suggested by Dr Hope's beautiful experiment, although this derives its meaning from the laws of convection, which Rumford first established.

(636.) Dr Hope on the maximum density point of water.

That water expands in bulk below the temperature of 39° or 40° Fahr. until it freezes, is a fact which had been asserted since the middle of the seventeenth century. But for 150 years its great improbability, and the unquestionable uncertainty introduced into the result by the irregular expansion of the containing vessel or glass of the thermometer, enabled sceptics in every generation to withhold their assent. Perhaps the last who doubted was the illustrious Dalton. He allowed himself however to be convinced by Dr Hope's experiment, in which the temperature of the denser and rarer water is measured by two thermometers placed at the bottom and top of a cylindrical jar, and nothing interferes with the natural tendency of a fluid to arrange its particles according to their specific gravity, the lighter resting on the heavier ones. It is to be regretted that Hope did not prosecute original enquiry, for which the conception of this experiment, and the mode in which he conducted it,[1] show that he had excellent qualifications. Hope was first the colleague, then the successor of Black in the chair of chemistry in Edinburgh; and in his time probably the most popular teacher in Europe of that science. He died on the 13th June 1844, in the seventy-eighth year of his age.

(637.) Rumford Prize—the Royal Institution.

Rumford's name will be ever connected with the progress of science in England by two circumstances; first, by the foundation of a perpetual medal and prize, in the gift of the Council of the Royal Society of London, for the reward of discoveries connected with Heat and Light; and secondly, by the establishment, in 1800, of the Royal Institution in London, destined, primarily, for the promotion of original discovery, and, secondarily, for the diffusion of a taste for science amongst the educated classes. The plan was conceived with the sagacity which characterized Rumford, and its success has been greater than could have been anticipated. Davy was there brought into notice by Rumford himself, and furnished with the means of prosecuting his admirable experiments. He and Mr Faraday have given to that institution its just celebrity with little intermission for half a century.

(638.) Rumford's last years and death.

Rumford spent his later years in Paris, where he died in 1814. The estimation in which he was then held may be judged of from the fact, that he was one of the eight foreign associates of the Academy of Sciences. He was very capable of having done more for science: the versatility of his talents, the accidents of his early life, and the strong hold which principles of philanthropy and public utility always exerted over him, account for the absence of more sustained and erudite researches. But in those very particulars he deserves to be cited as a practical philosopher, as to many things in advance of his age, and a benefactor both to science and to mankind.[2]

(639.) His opinions on the nature of heat important.

In the history of pure science Rumford will be chiefly remembered by his espousing the (not new) theory that heat consists in a motion of some kind amongst the particles of matter, in opposition to the opinions then so prevalent amongst chemists, which almost tended to regard it as an element capable of forming combinations. Rumford's view was mainly based on the facts of friction, which he showed to be irreconcilable with the notion of a change in the specific heat of the abraded matter, and to be seemingly inexhaustible so long as the force producing friction is continued. His conclusion was, that the heat then generated cannot be a *substance*, but an affection of body of the nature of vibratory motion. The amount of heat evolved in boring cannon is very

Derived from experiments on friction.

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[1] *Edinburgh Transactions*, vol. v.

[2] Rumford married (for the second time) Lavoisier's widow; his daughter (by his first marriage) became Madame Cuvier. Hence Cuvier's *Eloge* of Rumford contains the most authentic particulars of his life. Madame Rumford survived until a few years since, residing at Paris, where she formed a link between the *savans* of the age of Lavoisier, and those of the middle of the nineteenth century.

great, an operation with which, as we have seen, he was professionally connected. In one experiment, a steel-borer pressed with a force of 10,000 lbs. against gun metal, and revolving 32 times in a minute, generated in $2\frac{1}{2}$ hours the heat necessary to boil $18\frac{3}{4}$ lbs. of water. It is probable that Rumford carried his views so far as to infer a necessary and constant relation between the quantity of heat generated and mechanical action expended; and if we take an estimate of horse-power more conformable to reality than the *nominal* horse-power of Watt (33,000 lbs. raised 1 foot in the minute, which is too great), we shall find a tolerable approximation between his results and those now generally admitted. Davy favoured Rumford's theory, but the mechanical question remained for 40 years almost unconsidered.

(640.) Subject revived by Mr Joule. Mechanical effect of heat.

At length, about 1845, Mr Joule of Manchester endeavoured to establish a rigorous connection between the mechanical effort expended and the heat generated by friction; and he appears to have satisfactorily established (*Phil. Trans.*, 1850) that in the case of water agitated by beaters, the *work* expended by the fall of 772 pounds through 1 foot is capable of raising the temperature of a pound of water by 1° of Fahrenheit.[1] Mr Joule's experiments and inferences, however, go much farther than this, namely, that in all circumstances where heat is generated, it is at the expense of a precisely similar equivalent of mechanical effect; and conversely, that mechanical effect is never *used up*, without a corresponding evolution of heat, and that this is the case whatever be the fluids or other substances employed. Thus in the steam-engine the possible efficiency of the engine is only limited by the mechanical effort due to the heat given out by the condensed steam. So the heat given out by compressed air represents the force expended in compression; and even the heat produced by voltaic or magnetic electricity is that which corresponds to the work it might do. A step farther leads to the equivalence of heating effects by chemical combination to the amount of energy which, differently directed, might have been realized in the shape of work; and though a larger induction is still required to justify all the conclusions which the zealous promulgators of this comparatively new "mechanical theory of heat" have advanced, it cannot be doubted that there is a basis of important truth in the matter which well deserves farther enquiry.

§ 5. Sir John Leslie.—*Establishment of certain Laws of Radiant Heat.*—Pictet—Prevost.

(641.) Sir John Leslie—progress of the science of radiant heat.

The fact that heat is *radiant*, or passes through space in the manner of light, apparently disengaged from any material vehicle, became known at an early period. Porta in the sixteenth century, and the Florentine academicians in the seventeenth, had reflected heat by mirrors. Marriotte and Newton respectively assigned some of the laws which characterize it. Lambert, in the middle of the last century, made some real advances, but it was not until the very close of that period that heat in the radiant form was carefully and systematically studied. The group of philosophers simultaneously engaged on it consisted of Leslie, Rumford, Herschel, Pictet, and Prevost. The two last named were earliest in point of date; but as we owe to Leslie by far the ablest series of experiments, and which for many years, and even to the present time, have formed part of the body of science, we shall connect his name principally with this section.

(642.) His early studies;

Sir John Leslie, born in 1766, completed his studies at a very early age in the University of St Andrews. From boyhood he was remarked for a decided and independent turn of character; and as his favourite studies were mathematical, he for some time pursued them to the exclusion of the classics. Ultimately, however, he attained also to a respectable knowledge of these, and by his strong natural talents, and his love of reading, he acquired an immense stock of information on all sorts of subjects. This he displayed not only in his conversation, but also in his writings on technical and purely scientific matters, in which he frequently introduced without much apology illustrations from his miscellaneous reading, and even metaphysical disquisitions.

(643.) and essays on mathematics and electricity.

As is frequently the case in persons addicted to natural philosophy, his first original researches were connected with mathematics. Playfair, who was eighteen years his senior, encouraged and directed him; Ivory, who was almost his contemporary, and also his fellow-student at St Andrews, was perhaps no less influential in confirming his geometrical tastes. The former communicated Leslie's first original paper to the Royal Society of Edinburgh in 1788. It was on Indeterminate Equations, and was printed in their *Transactions*. Down to this period we have no record of his being engaged in original experiments; but it is probable that such was the case, for in 1790, and the following years, we have evidence not only of his having speculated on subjects of natural philosophy, but also that he had made experiments intended to confirm or refute prevailing theories. A paper on Electrical Theories was read to the Royal Society of Edinburgh, which, finding them reluctant to print, he withdrew, and he only published it more than thirty years after, when certainly it was not calculated to advance science in a perceptible degree. An essay on Heat and Climate, read at the meetings of the Royal Society of London in 1793, had not a more favourable reception; and though published twenty-six years later in *Thomson's Annals*, it was refused a place in the *Philosophical Transactions*. The author, no doubt, attributed these rejections to the boldness with which he criticised opinions currently received, and to the novelty of the views which were shadowed forth; but something is, no doubt, to be allowed for the real immaturity of these works, the involved and even inflated style in which they were written, and the questionable evidence for some of the conclusions. In these, and in some subsequent scattered papers in *Nicholson's Journal*, we observe, with all the faults, yet many of the merits of those researches which afterwards made him justly famous. We find acute observation, ingenious, if not close reasoning, considerable inventiveness in imagining experiments and in constructing apparatus, and a general tendency to express physical laws in a mathematical form. It must be confessed, that these merits were united to a good deal of dogmatism, and a somewhat supercilious judgment of persons eminent in science whose years and attainments should have commanded respect. This, however, is a fault which many ardent students not very conversant with the world have had abundant occasions to regret at leisure. Whether or not he believed Sir William Herschel to have had some share in the refusal of his paper by the Royal Society I do not know, but it is difficult, on other grounds, to understand the bitterness with which he expressed himself as to that eminent person, in connection with his experiments on heat.

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[1] To Rumford, I believe, is due the attempt (in conformity with this view) to ascertain the heat developed by the friction of fluids, for instance in churning (which, I think, was one experiment proposed by him), but I have not been able to find a reference to it amongst his scattered writings.

(644.) Travels. One of the circumstances which most contributed to encourage Mr Leslie's taste for experiment, was his engagement for above two years as tutor and companion in the family of the ingenious Mr Wedgwood. Another was the opportunities which he found or made for himself of foreign travel. With or without companions he visited, in the early period of his career, America, and most of the northern countries of Europe, particularly Holland, Germany, Switzerland, Sweden, and Norway. He also meditated a journey to Egypt and the East, a project reluctantly abandoned, and to which he reverted even in the last years of his life; but it was never carried into effect. Nothing, perhaps, fosters so surely a taste for science as such extended tours; and the acquaintance made under the most agreeable circumstances with foreign philosophers, and the familiarity gained with their language and experiments, contributes to it in no small degree.

(645.) Publishes his *Essay on Heat.* We have now come to the period of Mr Leslie's life when his character and position became established, the first by the publication of his *Experimental Inquiry into the Nature and Propagation of Heat*, in 1804; the latter by his appointment to the chair of mathematics in the University of Edinburgh in 1805. I shall first say a few words on his character as a mathematician.

(646.) Mathematical writings. Mathematics were, as has been stated, his earliest pursuit, and he cultivated them with great industry and success. His adviser, Playfair, was attached to the methods of the foreign mathematicians; and Leslie no doubt acquired from him, as well as from his continental friends, a taste for the notation of Leibnitz, then hardly employed in this country, but which he uses in his work on Heat, and elsewhere. Nevertheless, his real preference appears to have been decidedly geometric. He almost always prefers demonstrations, whether in mathematics or natural philosophy, in the manner of Huygens and Newton. He could hardly be called a discoverer in mathematics; but his work on Geometrical Analysis and the Higher Curves shows much taste and knowledge, and is justly commended by Chasles and other foreign writers. His attempt to replace Euclid's *Elements* by a new work on Elementary Geometry was not more successful than such attempts have usually been.

(647.) Growing importance of the subject of radiant heat. Unquestionably, the bent of Leslie's mind was to physical research, in which he showed a peculiar talent; and his selection of Heat was, as we have hinted, well-timed; since there appeared a convergence of attention to the subject, such as usually heralds some eminent discovery. The doctrines of heat in combination, of which we have already spoken, had engaged the attention of Black, Cavendish, and Lavoisier; the subject of meteorology, in which Leslie took the greatest interest, was becoming a science in the hands of De Saussure and Deluc; whilst Pictet repeated (without being aware of the anticipation) the curious observation of Porta on the apparent concentration of cold by a concave mirror. As this experiment really opened anew the subject of radiant heat, we shall dwell for a moment on Pictet's labours and their results.

(648.) Pictet of Geneva. Geneva was at this time nearly in the zenith of its reputation as a nursery of the sciences. The most eminent and independent of its citizens were proud of being also amongst its instructors, and the office of professor was then, as it still is, considered one of the most honourable in the state. About 1790 De Saussure, the most eminent physical geographer of his time, was in the vigour of his intellect, and amongst his friends and coadjutors MARC-AUGUSTE PICTET held a conspicuous place. The latter was professor in the Academy, and being a person of popular manners and great information, was known and esteemed by the learned throughout Europe. He was the author of numberless papers in a scientific journal which he edited; but his work on fire—*Essai sur le Feu*—published in 1791, was his principal publication. It contains some good observations on latent and specific heat; and on the power of different kinds of surfaces to reflect and absorb it. He noticed the different heights at which a blackened and a bright thermometer stand even when exposed to common daylight; but so far as I have observed, he did not distinguish the effect of colour in absorbing heat when that heat is accompanied by light or the reverse; and, indeed, this portion of his work stops short on the threshold of most interesting enquiries. He showed that radiant heat travels with great velocity, and observed the heating and cooling of thermometers in exhausted receivers. His work also contains observations on hygrometry, on some points of meteorology, and on the heat of friction. Indeed, its chief fault is embracing so many topics in so short a compass, thus preventing him from thoroughly examining any one of them. To Pictet is due the establishment of meteorological observations at the convent of the Great St Bernard, which are amongst the most interesting which have ever been made, and which are still continued. He died in 1825, at the age of seventy-three.

(649.) Prevost—moveable equilibrium of heat.

The interesting experiment of the reflection of cold led Pierre Prevost, one of Pictet's colleagues, to devise the theory of "the Moveable Equilibrium of Heat." His idea is, that heat is a substance associated with bodies, of a highly elastic nature, and continually given off from them in proportion to their temperature, which may represent the *tension* of the imaginary elastic fluid. When the temperature of a body is stationary, it is (according to this view) because it receives by radiation from surrounding bodies exactly as much heat as it parts with in the same way. The general structure of this theory was sustained by the experiments of Leslie, and by some later ones on the law of cooling by Dulong and Petit, which, indeed, realize it in a remarkable manner. Prevost first published his ideas in 1791, in the *Journal de Physique*, and afterwards in a special work. Prevost was a man of an active and vigorous, rather than profound intellect. He was a foreign member of the Royal Society, and died in 1839, at the advanced age of eighty-eight.

(650.) Leslie's *Essay on Heat*—Differential thermometer.

We now come to speak of Leslie's important *Essay on Heat* which received from the Royal Society the distinction of the Rumford medals, and which procured for him a European reputation. It is a work difficult to analyze, from the very fact, that its construction is fragmentary, and its arrangement desultory and obscure. Our limits will only allow us to mention the methods of research and their chief results. As a thermoscopic instrument, he used a modification of the common air thermometer (which last had been employed by Pictet), which, having two balls at a certain distance, connected by a bent tube containing a coloured liquid, showed the *difference* of temperature of the balls; and being hermetically closed, was free from the disturbing variation of atmospheric pressure. This he called the differential thermometer. A similar instrument had been described by Sturmius in the seventeenth century. Whether Leslie had any previous knowledge of this does not appear; but, as Dr Young very correctly observes in one of his anonymous critical articles,—"The principle of the differential thermometer is too simple to be called an invention, and it is only by its ingenious application that Professor Leslie has made it an object of attention." He usually employed as a source of heat a canister of block tin, filled with boiling water, and having sides with different surfaces. The radiating or emissive effect of these surfaces was measured by the rise of the thermometer exposed to their successive influence in the focus of a metallic reflector. The result showed a great variety of effect, varying from 100 when the surface was blackened, to 12 when it was of polished metal. The absorptive power of surfaces to non-luminous heat is also in exact proportion to their emissive power—a property which seems essential for preserving the equilibrium of like temperatures.

Emissive effect of different surfaces.

(651.) Law of emanation of radiant heat.

Another and not less important law clearly established by Leslie was this, that the radiation of heat from a plane surface takes place with unequal force in different directions.[1] When the specific heating power or density of the calorific rays is estimated in a direction perpendicular to the surface from which it emanates, it is found to be a maximum. At any other angle with the surface, it varies as the sine of the angle. This law (which Fourier showed later to be necessary for the equilibrium of temperature) obtains also in the case of light. Hence the apparent specific brightness or warmth of a surface is the same under whatever angle it is viewed with reference to the plane of the surface, which, when placed obliquely, contributes rays from a larger extent of surface, owing to the foreshortening, but being weaker in the same proportion from every point, the aggregate effect is the same. Some interesting experiments were made on the number of coats of isinglass necessary to effect a complete transformation of the metallic into the gelatinous surface, which was found to be considerable; and, in like manner, the reflective character of metals was only very gradually destroyed by varnishing. This observation, rightly interpreted, showed that some solids are permeated by radiant heat, a conclusion which Mr Leslie utterly rejected.

(652.) Follows the inverse square of the distance.

Another fundamental experiment less decisively proved was, that the law of radiation varies inversely as the square of the distance. Perhaps the most convincing, as well as the simplest proof of this has been given more recently by Melloni. If a delicate thermometer or other apparatus for measuring radiant heat be confined in a case, so as only to admit rays coming within a definite angular space—and if the instrument be placed in front of an indefinite plane (such as a wall) hotter than itself—the rise of temperature will be precisely the same, whatever be the distance at which it is presented to the heated surface.

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[1] This result had already been anticipated by Lambert; *Pyrometrie*, p. 197.

(653.) Influence of colour on radiant heat.

The influence of colour on the heating of bodies was considered by Leslie in an original manner. It was found to be effectual only when the radiations are luminous. A thermometer painted black or white (provided the *texture* of the surface be the same) parts with its heat, and also absorbs the heat derived from such a source as boiling water, in an almost equal degree. The effect depends chiefly on the degree of polish or condensation of the surface. But with luminous sources of heat the case is widely different. This subject had been carefully considered previously to the date of Leslie's work by Sir W. Herschel, who had studied the absorbing power of different colours on the sun's rays. Black and white form the two extremes, and Leslie availed himself of this principle to construct his photometer, which certainly (whatever may be its defects) is an elegant modification of the differential thermometer. It is an instrument having one ball of black, the other of pellucid glass, and united by a tube of the form of the letter U, containing sulphuric acid tinged red as an indicator. As the texture of the surfaces of both balls is the same, dark heat is equally absorbed by both, and the indicating liquid remains stationary. But in the sun's rays, or even in common daylight, the dark ball becomes most heated; and it is not unreasonable to conclude, that *when the source of heat remains the same*, its variations of intensity are correctly shown. Leslie, however, erred in considering that it was applicable to measuring light differing in origin and quality on a comparative scale; and this error he unfortunately persevered in, after unquestionable experiments had shown its fallacy.

(654.) The laws of cooling under various circumstances.

The Essay on Heat contains an elaborate and ingenious research into the law of cooling of bodies, including the effects of mass, surface, contact of air, currents of air, and likewise of inclosure of the cooling body in successive envelopes or thin cases; and the author ingeniously compared the results of actual experiment with formulæ based on principles more or less theoretical. But a fundamental error unfortunately runs through all this research, and shows in a striking manner the fatal influence of theoretical preconception steadily maintained through a course of experimental enquiry. He starts with the notion, that the presence of air is essential to the propagation of Heat, generally called "radiant." In fact, for radiation he usually substitutes the word "pulsation," and ascribes the effect of surface in modifying the cooling of bodies to its faculty of transmitting pulsations or tremors, more or less readily, to the vehicle of the air. He was indeed compelled to admit that air had a double agency; one "abductive," as it draws off heat by contact and by what is generally called "convection," that is by currents which the communication of heat itself produces; the other, "pulsatory," which corresponds to what is usually termed radiation, but which Leslie persisted in believing to be due to tremors propagated in air, after the manner of sound, and with the same velocity. In the concluding chapter of the work before us he considers the cooling effect of different gases, and of air of different degrees of rarefaction; and this last experiment might, one would have thought, have satisfied him of the fallacy of his opinion; since, taking his own numbers, when air is rarefied 1024 times, the "pulsatory energy" is only diminished one-third part. In fact, it appears as if his work broke off abruptly, when the course of observation became irreconcilable with the opinions advanced in the early part of it.

Leslie's peculiar views on the propagation of heat.

(655.) His minor writings—Freezing experiment.

After this analysis of Leslie's greatest contribution to science, I cannot afford space to dwell upon his minor inventions. I pass over them, however, with the less regret because they have been fully dwelt upon in his "Dissertation," of which the present is a continuation, and in his articles on Cold and Meteorology in the *Encyclopædia*. The most original and important of these was his very beautiful process of producing ice in quantity by the cold of evaporation, in the receiver of an air-pump; rendered effectual by his ingenious use of absorbent surfaces for withdrawing the vapour. This experiment was completed in 1811, and attracted much attention. It was connected with his researches on hygrometry, to which he also adapted his differential thermometer. But in the development of this difficult theory, he was less successful, nor indeed could he well be so, whilst he adhered to the old opinions respecting the affinity of air for moisture.

(656.) Close of his career.

Having filled the Mathematical Chair from 1805 to 1819, Leslie was in the latter year translated to that of Natural Philosophy, vacant by the death of Playfair. He had a good collection of apparatus, and devised many ingenious experiments. In 1820, he was elected corresponding member of the Institute of France, and died on the 3d November 1832, at the age of 66, having received the honour of knighthood, on the recommendation of Lord Brougham, but a few months before.

(657.) His philosophical character in some points defective

In closing this brief sketch of Sir John Leslie's career, we cannot fail to observe the combination of unusual powers with unusual drawbacks to their complete and vigorous exertion. Whilst he had the chief merits, he had also the most serious defects, of the self-formed student. He was ardent and ambitious in the pursuit of knowledge. He must have been for many years a hard, if not a methodical student; he united good mathematical knowledge with a real love of experiment; he was gifted with a strong memory, and confident in the exercise of all his powers. Why, with so many advantages he did not achieve more, nor put forth even what he did to greater advantage, was mainly because he yielded to the guidance of an imagination which often carried him into fanciful speculation, yet which was strangely united with dogmatism in maintaining what he had once maintained, and a disposition to accuse others of misinterpreting nature, whenever they arrived at conclusions inconsistent with his own.

(658.) In such sciences as those which he chiefly cultivated, — sciences eminently progressive, imperfect, and dependent on experimental proof,—a just appreciation of the labours of others is one of the most essential parts of the philosophic character, whilst an absence of it infallibly condemns the dogmatic theorist to be gradually left behind, even in the paths which he had at first trod with the greatest distinction. With few exceptions, Sir J. Leslie carried his scientific views of 1804 with him to the grave. The possibility of the passing of heat, except solar and highly luminous heat, through any solid body, such as glass, though proved by Maycock, De la Roche, and Powell,—the existence of dark heating rays in the sunbeam, less refrangible than the red, demonstrated by Herschel, and afterwards confirmed by many others,—the doctrine of gases and vapours as laid down by Dalton,—the maximum density point of water shown so ably by Hope and Rumford,—the existence of climates in the arctic regions of which the mean annual temperature does not exceed 0° of Fahrenheit, proved by Parry and his successors,—all these, and many other demonstrated truths in his own peculiar walk of science, were, we fear, practically ignored by him throughout life.

(659.) Merit of his experimental researches. But we willingly leave the ungrateful task of indicating defects. Let us recollect rather with pleasure how much we owe to his beautiful discoveries. It is perhaps not an insignificant test of their originality, that though they were generally adopted (at least to the extent which his own experiments justified), Leslie's observations were but rarely repeated, and that only in the way of general confirmation and illustration. I mean that for a great many years the path which he had opened, and the methods which he described, were not seized upon by others, as leading to a sure course of discovery. Until the time of Dulong, his experiments on cooling were perhaps never carefully resumed, and a very great number of his subjects of enquiry were only taken up thirty years after their publication, as we shall see in a future section.

(660.) The observations of Herschel on the Refrangibility of Solar Heat, I shall include in the notice of the experiments of Berard and De la Roche, to which we shall presently turn.

§ 6. Fourier.—*Mathematical Theory of the Conduction of Heat.* Lambert; Poisson.—*Temperature of the Earth and of Space.*

(661.) Theory of the conduction of heat —Lambert. It is stated by Arago, that when the Academy of Sciences, above a century ago, proposed as a prize subject, "La Nature et la Propagation du Feu;" adding, "la question ne donne presque aucun prise à la géometrie,"—a majority of the candidates treated of the methods of preventing the burning down of houses! It is true, however, that on that occasion, Euler sent a memoir which, though crowned, was unworthy of his genius. Lambert in his "Pyrometrie," in 1779,[1] had the rare merit of laying the foundations of the science of conduction. He solved correctly this question:—"If a thin conducting bar of indefinite length be kept with one extremity heated to a constant degree above the surrounding space, required the temperature of any point in the axis of the bar?" The solution is, that the temperatures, or rather excesses of temperature, diminish in a geometric ratio, at distances reckoned in arithmetical progression, from the origin of the heat.[2] In this solution it is assumed, (1.) That the flow of heat along the bar, is at any point proportional to the rapidity with which the temperature at that part of the bar is lessening as we recede from the source; in other words, that the flow of heat from the hot part to the cold part, is more rapid in proportion as the difference of temperature of two sections of the bar at a given short interval is greater. (2.) That the bar parts with its heat to the surrounding space, exactly in proportion to its excess of temperature at every part.

(662.) Biot. This beginning, which perhaps like many of Lambert's other writings was not very generally known, had no sequel until 1804, when M. Biot attempted to find the differential equation of the general movement of heat on the same principles. But the form which he obtained, including a mathematical solecism, betrayed some error in stating the conditions. Three years later Fourier had more success. But, conformably to the plan of this discourse, I shall premise some facts regarding his early career, which was far from commonplace.

(663.) Fourier—his early history. Joseph Fourier was born in 1768, at Auxerre in France. He was of humble parentage, and being early left an orphan, was educated by the Benedictine monks who, singularly enough, conducted with success in that town a military school. It seemed his fate to become either a priest or a soldier; yet he was neither, though ere long familiar with camps. He became first a pupil of the old normal school of

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[1] *Pyrometrie, oder, von Maasse des Feuers und der Wärme.* Berlin, 4to, 1779. This work was posthumous, and contains many riginal observations on Thermometry, Conduction, Solar Radiation, and Climate.

[2] *Pyrometrie*, p. 184.

Paris, when Lagrange, Laplace, and Berthollet were amongst the professors. He had already presented to the Academy, at the age of 21, a paper on the numerical solution of equations, a subject of predilection with him, and to which we shall presently return. After leaving the Normal School, he was named one of the original professors of the Polytechnic School, a station of which he was justly proud, but from which he was withdrawn by the requisition to join, along with Monge and other *savans*, the Expedition to Egypt under Napoleon. It was the singular fancy of that extraordinary man, to create an *Egyptian Institute*, of a constitution similar to that of France. Fourier was perpetual secretary. But it proved little better than a waste of talent. The arts of Egypt were not regenerated, and France was despoiled of some of her ablest philosophers. Fourier had quite as much to do with battles and treaties as with equations and experiments. Yet he often referred afterwards with partial recollection to those stirring times, and recounted, with the ardour of a somewhat garrulous temper, the valiant feats of arms which he had witnessed. Fourier edited the account of the Expedition to Egypt, and wrote the historical preface, the composition of which ultimately procured for him a seat in the *Académie Française*.

The Egyptian Institute.

(664.) Fourier first states correctly the analytical form of the problem of conduction.

On his return to Europe, he was appointed Prefect of the Isère in 1802, and Grenoble became his home for some years. Whilst he devoted a just share of his attention to his public duties, he found time to produce his greatest work, *The Analytical Theory of Heat*. His first paper on this subject dates from 1807. It was communicated to the Academy of Sciences, but not printed. The subject was however proposed for a prize, to be decided in 1812, when Fourier's essay was crowned, but, strange to say, not published. The cause, it is to be feared, lay in the jealousy of the greatest mathematicians of the age. Laplace, Lagrange, and Legendre, the committee of the Academy, whilst applauding the work, and admitting the accuracy of the equations of the movement of heat thus for the first time discovered, insinuated doubts as to the methods of obtaining them, and likewise as to the correctness of the integrations, which were of a bold and highly original kind. These disparaging hints were not supported by any precise allegations; and we can scarcely blame Fourier for feeling indignant at the tyranny of the mathematical section, and little disposed to regard with favour the few and comparatively insignificant efforts of several of its members subsequently to ratify and extend the discoveries which he had unquestionably made. The manuscript, after lying for twelve years in the archives of the Institute, where it was consulted by different persons, was finally printed, *word for word*, as it stood in 1812.[1] Fourier's long absence from Paris in a remote provincial town, rendered this indignity possible at first; and afterwards, it was his misfortune to be unable to hold a political station without offence, amidst the violent intestine conflicts with which France was afflicted. He alternately displeased his old master Napoleon and the Bourbons, and the consequence was, that after the Restoration he found himself dispossessed of every employment, master of not one thousand pounds, and refused by the government even a seat at the Institute. This indigence, so honourable to himself, and this neglect, so disgraceful to others, tended, no doubt, to increase an irritability, such as intense mental exertion often produces, and which the injustice of his scientific countrymen had already aggravated. Finally, however, he received a modest post connected with the civil administration of the department of the Seine; he was also elected a member of the physical section of the Academy of Sciences, and he finally became perpetual secretary of that body.

Tardy publication—rivalry in the Institute.

(665.) His physical precision—experiments.

Fourier's papers on Heat show a remarkable combination of mathematical skill with a strict and precise attention to physical considerations. In this he excels almost every writer of his time, and especially his colleague and younger rival, Poisson. His experimental skill is not to be so highly praised, although he illustrated several of his solutions by actual trials, which he submitted to calculation, and showed to agree with theory. Their degree of precision, however, hardly allows them to be considered as *tests* of theory.

(666.) Assumptions of the Analytical Theory.

Fourier assumes the correctness of Newton's law, as well for communication of heat from point to point of a solid, as for the external radiation by which it parts with its heat into the surrounding space. In the former case, the flow of heat is proportional to the rapidity of the depression of temperature, in the direction in which the motion of the heat is considered; in the latter, it varies as the excess of temperature of the *surface* of the hot body above the surrounding space, affected, of course, by a constant depending on the radiating power of the surface. These, as I have said, were also the Postulates of Lambert's solution. Fourier's researches, fortunately perhaps, preceded for the most part Dulong and Petit's enquiry into the true law of cooling. I say fortunately, since otherwise Fourier might have been discouraged from attempting the solution of problems which are highly important even in an approximate form.

(667.) Necessity of the law of emanation.

With regard to the law of radiation, Fourier had the merit of showing, for the first time, the *necessity* of Leslie's experimental law of the intensity of emanated heat being proportional to the sine of the angle which the direction of emanation makes with the surface. This he considered both mathematically and physically. Mathematically, he showed that were this law not true, a body might be maintained for an indefinite time within an envelope of constant temperature, and yet never acquire that temperature, even approximately; and physically, considering that radiation proceeds not from a mathematical surface, but from a material physical stratum of an imaginable thickness, but which rapidly absorbs the emanations proceeding from the inferior particles, he proved that the attenuation due to oblique emanation will follow Leslie's law, independent of the precise rate of absorption in traversing the physical surface.

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[1] See Fourier's note at the commencement of his paper, in Memoirs of the Institute for 1819 (printed 1824).

(668.) Definition of conducting power,

Fourier takes extraordinary pains to define and justify every step of his demonstrations. He has the great merit of having first given a clear definition of conducting power, or *conductivity proper*, which is this:—"The number of units of heat (measured by the weight of ice which it can melt) passing in unit of time across a square unit of surface of an infinitely extended plate bounded by two parallel surfaces at unit of distance which are respectively maintained at the freezing and boiling temperatures (unit of difference of temperature)."[1] In like manner, the "exterior conductivity" expresses the number of units of heat parted with by unit of surface to the air and surrounding space, when the difference of their temperature amounts to unity.

and of "exterior conductivity."

(669.) Fourier's *Thèorie Analytique de la Chaleur.*

Account of the Thèorie Analytique de la Chaleur.—The problems considered by Fourier in his *Thèorie Analytique*, refer principally to the propagation of heat in homogeneous conducting solids of definite forms, and in some cases maintained in certain parts at fixed temperatures.

(670.) Instances of problems solved by him.

The number of examples fully worked out is very small, but they may be referred to the following classes:—(1.) When some part of a solid has an indefinite source of heat applied to it, the remaining surface being exposed to the air, or having determinate temperatures maintained at certain parts. In this case, the state of the solid in regard to heat is *permanent*, or independent of time; and the problem is to assign the temperature of each part, and the flow of heat through that part in a given direction. (2.) To assign the temperature of every point of a solid primitively heated, either uniformly or after any assigned law, and at any given moment. (3.) To solve the last question only in the case where the cooling at the surface has been going on for an exceedingly long time.

(671.) Stationary condition of heat in a slender bar.

Of the first class of problems, the slender bar heated by a constant source of heat at one end, and exposed to the cooling influence of radiation and of the air, which had been treated of by Lambert, is the simplest and most important. The temperature of any thin slice perpendicular to the axis of the bar, is the result on the one hand of the heat which it acquires from the hotter slice nearest to it on the side of the source of heat; and on the other, of the heat with which it parts to the slice next beyond and also to the air in contact with the exterior surface of the slice and by radiation from the same surface. The solution of this problem is that of a simple differential equation of the second order, and the result is the diminishing geometrical progression of temperature already mentioned. This has been approximately confirmed by some careful experiments of M. Biot, which indeed are nearly the best which we yet possess on the subject. But instead of drawing from them, as he does, an argument for the accuracy of the Newtonian law of cooling, the diminution of temperature along the bar is far more rapid at first, and less afterwards than that law indicates. In fact, the apparent agreement of the formula is owing to the use, in a case to which it does not correctly apply, of that often misapplied rule of the doctrine of chances—the method of least squares.

(672.) In an infinite solid.

The solution of another case of stationary temperature,—an indefinite solid bounded by three infinite planes (two of which, B, C, are parallel, and the third, A, perpendicular to both) having determinate temperatures,—requires the introduction of a species of analysis, in which Fourier acquired great dexterity, but which is of so subtle a kind as to have created doubts in the minds of the committee of the Institute to which the Memoir was referred, and to have been a source of some controversy and much discussion since. Fourier contrives to express, by an infinite trigonometrical series, the law of temperature in such a solid, which shall not only satisfy the differential equation of the equilibrium of heat, but also the conditions of temperature at the bounding planes, B and C, which being zero by the problem, the value of the temperature which, up to that point was finite, suddenly comes to nothing, and has no value beyond. This problem leads to a long digression on the possibility of expressing by trigonometrical series, quantities which vary according to any conceivable law and of determining the co-efficients of the successive powers of the sines and cosines employed. The theorem to which Fourier is led, in which any function of x is expressed by a series of definite integrals, including $\sin x$ and $\cos x$, is known by his name.

(673.) Movement of heat in a sphere.

The problem, however, which Fourier most elaborately treated, belongs to the 2d and 3d class,—namely, the cooling of a sphere primitively heated in a given way, but so that points equi-distant from the centre have a common temperature.[1] It might be expected that the symmetry of the conditions would admit of a simple solution; and such indeed was sought by Professor Playfair long before, in a paper in the *Edinburgh Transactions*, with reference to Geological Speculations. It was, however, by no means sufficiently general. It is shown by Fourier, that even in the simplest supposable case—that where the temperature of the sphere was originally uniform—the resulting expression for the temperature of any stratum at any time, though capable of algebraic expression, cannot be assigned in finite terms, and no attempt has been made to evaluate it generally. The special cases which have been considered, are when the sphere is extremely small, or has been cooling for a very long time.

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[1] Let F be the flux of heat measured as above, K the constant of interior conductivity, z an ordinate measured across the thickness of the plate, and v he temperature of the stratum of which z is the ordinate; then $F = -K\frac{dv}{dz}$; in the permanent state the temperature varies uniformly from stratum to stratum. When the thickness and difference of temperature both are equal to unity, K=F. The expression $F = -K\frac{dv}{dz}$ manifestly expresses the Newtonian Law, interpreted by Fourier as stated above.

(674.) Sources of complication in the Problem of the Sphere.

The extreme complication of even such apparently simple cases when solved in all their generality consists in this, that the flow of heat across each part is in fact dependent at each instant on the state of heat in each other part, and this distribution of the whole is equally unknown with the local distribution on which the movement of heat in each part depends. To this must be added the peculiarity of conditions at the surface, where the temperature undergoes an abrupt change. The law according to which the superficial particles radiate heat, is also different from that according to which they receive it from the interior. When a body uniformly heated to a considerable temperature cools in air, the subtraction of heat from the surface commences with great rapidity, the excess of temperature of the superficial particles being very much greater than it ever can be afterwards. The drain of heat from the interior of the sphere is at first nearly imperceptible. The exterior cooling will by and by become slower; and the degree in which it takes place, will depend upon the rapidity with which the conducting mass of the sphere is able to supply fresh heat to the surface; then the rate of superficial cooling will become relatively somewhat accelerated, and a fresh drain will take place from the interior towards the surface. It is only in the case of exceedingly small bodies, or those of an infinite degree of conductivity, that the body will cool according to a simple law. In all other cases, there will be characteristic periodical inflections in the course of cooling. These, no doubt, are represented in Fourier's series, if it could be numerically calculated; and it is to be desired that some attempt were made to represent it approximately. When the cooling has endured for a very long time, these gushes of heat cease altogether; the surface has attained nearly to the temperature of the surrounding space, and the drain of heat from the interior is so slow, that the progression of temperature is very gradually and slowly disturbed.

(675.) Application of these principles to the thermal condition of the Earth.

Application to the Thermal condition of the Earth.—This last case has been discussed by Fourier with great address, relatively to the present condition of the Earth, considered as a mass which has been once at a high temperature, of which we have evidence in the general increase of heat as we descend in mines, or when we penetrate its crust by Artesian wells. The surface of our planet receives a large amount of heat annually by absorbing the sun's rays, but parts with it by radiation into free space, to an extent which preserves a sensible uniformity of temperature from age to age. The considerations connected with the subject are these:—(1.) The proper heat of the earth, and how much heat reaches the surface from the (perhaps) still incandescent interior; (2.) How much heat do we receive from the sun, what share of it enters the surface, and how far, and according to what periods does the influence of the seasons extend below the surface? (3.) What is the amount of refrigeration of the earth's surface?—how does the atmosphere affect it? and, if the cooling be due entirely to radiation, what are we to set down for the *temperature of space*, so as to account for the heat lost?

(676.) The proper heat of the globe;

First, As to the proper heat of the globe. Not to go further back than the last century, the incandescence of the earth's nucleus was assumed as very probable by Buffon and other popular writers, and their opinions were, on the whole, confirmed by the progress of observation. The existence of volcanoes was, of course, an obvious argument; another was, that if the earth were once hot it must be still cooling; consequently, climates are continually becoming colder, especially in the Arctic regions, which it was supposed depended most on the supply of heat from within. In evidence of this change were quoted, not only the remains of elephants found interred with flesh and skin in the midst of Siberian ice, but also the unequivocal proofs, so well known to geologists, that at a period indefinitely more remote, tropical plants of gigantic growth, and animals of a class which now frequent only southern seas, appear to have lived and flourished in high northern latitudes. But even in the time of Buffon, attention was directed to a fact yet more important for the theory of heat, namely, the increase of temperature observed in deep mines. Notwithstanding many sources of doubt and confusion, such as the heat from candles, and from men at work in mines, from chemical changes in some cases, and from the increased density of the air, the fact of the increase is now well established, and also its rate of progression with more certainty than in the time of Fourier. On an average (including the best data of all, those yielded by Artesian springs), the

manifested by the increase of heat in mines.

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[1] The problem of the *Armil* or ring, heated at one or several points, is one which offers considerable facilities for its solution, but the results are of little utility, the form being so peculiar; and even as a test of theory, the variations of temperature from point to point are insufficient under the limited conditions in which the numerical solution is practicable.

increase appears to be 1° Fahr., for 50 or 60 English feet of descent. Fourier first undertook to enquire, Whether, supposing the earth to have no primitive internal heat, the continual action of the sun might not produce the increasing temperature observed. But he found, on the contrary, that there is no such tendency, and that after a long time, the temperature at any moderate depth below the surface (but beyond the varying influence of the seasons) will be constant. Now, observations on the temperature of mines and Artesian springs extend to the depth of 1700 English feet, and the influence of the seasons is usually quite extinct (in this latitude) at 50 or 60 feet. The nearly uniform increase beyond is therefore due to a source of heat within, or, what amounts to the same thing, to the relatively warmer state of the nucleus. The analysis of Fourier shows, that the variation of temperature in the successive strata of a sphere, cooling with excessive slowness, is very closely allied to the flux of heat which passes through it, and which is spent by radiation or otherwise at the surface. The result is exceedingly striking, and may be considered as remarkably well established; the flow of heat from the interior contributes to raise the temperature of the surface by only *one seventeenth of a degree* of Fahrenheit; or would melt annually a stratum of ice $\frac{1}{40}$th inch in thickness. This is all the refrigeration which the earth's surface can ever suffer on this account, and in its present state of cooling, it would take millions of years even to reduce it by one half. So little ground is there for the belief of Buffon and his friends, who imagined that the destruction of animal and vegetable life must rapidly ensue by reason of the diminishing central heat.

Its insignificant effect on climate.

(677.) Depth of the fluid nucleus.

Again, the depth to which we must descend in order to reach a temperature sufficient for the supply of molten lava, is not excessive: for this depends entirely on the conductivity of the earth's crust, which we know to be very small. A familiar instance occurs in streams of recent lava, where a crust soon forms, on which a man may walk safely, yet only be separated by a foot or less from the fiery liquid. Fourier calculated that the temperature of incandescence may prevail at a depth within the earth of only about 15 English miles, without affecting the superficial temperature by more than a small fraction of a degree.

(678.) Cause of secular change of climate.

As it seems scarcely possible to ascribe some, at least, of the geological effects already mentioned to a cause of which the variations are imperceptible in such vast periods, other writers have suggested different possible explanations. One which appears to have considerable probability, is that of Arago, that the heat emitted by the sun has a secular rate of change; in other words, that our sun is a variable star.

(679.) Effect of the sun's heat on the earth.

Secondly, As to the effects of the sun's heat on the earth. It has been already stated that Fourier showed that below a moderate depth, the heat of the earth would be uniform and invariable, so far as solar radiation is concerned. At smaller depths, it will vary according to the season of the year, and these variations will at all depths be gone through in the same period with the variation at the surface, which, is of course annual, but the inflections follow a peculiar law in each latitude and climate, and even in one year compared with another. Within the depth to which the influence of the seasons extends, the amount of the range of temperature continually diminishes, nearly in a geometrical progression, and at length it becomes insensible. At increasing depths, the periods of maxima and minima are continually retarded, so that at a certain depth, the earth is hottest in winter and coldest in summer. A smaller fluctuation of the same kind, and penetrating to a smaller depth, follows the diurnal range of temperature. The manner in which these interesting phenomena are connected with the conducting power and specific heat of the earth's crust, was clearly pointed out by Fourier.

(680.) Theory compared with experiment.

Before as well as after these theoretical investigations, observations on thermometers sunk to different depths in the ground had been made, and the results confirm these conclusions of theory in every respect. Such observations were made by De Saussure, Leslie, Arago, Quetelet, and other experimenters, including the writer of these pages, who caused careful experiments to be made for five years, on three sets of thermometers, placed in different kinds of soil and rock, extending to a depth of above 25 feet. By means of these, the conductivity of those various soils was determined with accuracy, and data afforded for subsequent enquiry.[1]

(681.) Total quantity of heat received by the earth from the sun.

Amongst the most interesting enquiries connected with this subject, is the total quantity of heat received in a year from the sun by the absorptive action of the earth's surface; but this does not appear as yet to have been successfully answered. Nevertheless, M. Pouillet, from merely experimental data, considers that he has proved that the amount of solar radiation which reaches the earth would melt in a year an average thickness of 31 mètres of ice, all over its surface, provided that it were entirely absorbed. Poisson has obtained a result four times less, and estimates the effect of the sun in raising the temperature of the climate of Paris at 24 centigrade degrees, a result incredibly small.

(682.) The temperature of space—

Thirdly, On the temperature of space. Fourier was probably the first who introduced this idea into science. The term perhaps is a doubtful one and liable to misconception, but the object of the enquiry admits of being precisely stated. The researches of

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[1] See *Transactions of the Royal Society of Edinburgh*, vol. xvi., where a history is given of the observations previously made.

Dulong and Petit[1] upon the cooling of a body by radiation only within an envelope having a temperature lower than itself, include, as a particular case, that in which the body receives *nothing* from the envelope,—when the radiation is entirely that of loss without any gain; and yet the cooling proceeds with a finite velocity. It could not with any propriety be said in such a case, that the temperature of the space in which the body cools is infinitely low; it cannot be said to have any temperature at all.

(683.) defined by Fourier. Now, in the case of our globe and its atmosphere, we have a heated mass, suspended as it were, in space. If there were no other bodies in the universe, the earth must by degrees lose its heat. We know indeed that it is cooling. The proportion of its native heat annually emitted, would melt a crust of ice $\frac{1}{40}$th inch thick. This heat is dissipated in space. It may therefore be enquired, whether a sphere of known conducting power and of known temperature at the surface, is parting with its heat to space at a rate which supposes it to radiate without any requital, or whether it receives from space (or the bodies which space contains, independently of the sun) any portion of the heat which it thus dissipates. To solve this question, we must evidently know with great accuracy the radiating power of the surface of the earth, than which, unfortunately, no datum is more completely uncertain: and the influence of the atmosphere (which is truly a part of the earth) renders the solution still more indeterminate. It is not known what method Fourier took to arrive at a numerical result, but it is well known that he obtained it in a way which appeared satisfactory to himself, and that he often referred to it. He supposed the "temperature of space" to be 50° or 60° below zero on the centigrade scale, and believed he did not err in fixing it by more than 8° or 10°. By this we understand, that after infinite ages, the earth, or any other body placed in the same situation and previously heated, would attain this temperature and no lower.

(684.) This slight sketch gives an imperfect idea of the extent and originality of Fourier's labours. But enough has been said to show, that he must rank amongst the most considerable philosophers of his day. That he excited the jealousy of the great mathematical geniuses of the previous generation, and that his new train of research, though fully accepted by those who succeeded him, has as yet received but slight extension at their hands, are facts which concur to prove his originality and merit. That he did not solve more cases of the propagation of heat, and that some of his solutions are so complicated as hardly to be such in a practical sense, show only the extreme difficulties of a subject which touches every where the boundaries of existing mathematical knowledge. In the opinion of many persons, it is to be desired that some at least of the problems of conduction were treated in a somewhat different way, and approximations obtained by the application of a less abstruse calculus. But towards this desirable result, little has yet been done.

(685.) Writings of Fourier on pure mathematics. As a pure mathematician, Fourier occupies a distinguished rank. His conversion of functions of every kind into series of periodical quantities—his treatment of problems, involving discontinuous laws—his solution of higher differential equations—are all important additions to analysis, to the improvement of which, as he has himself very justly observed, physical problems are ever the most important avenues. Such considerations as Fourier treated of could hardly have entered into the mind of a mathematician not guided by a specific physical enquiry. His favourite subject of the solution of Numerical Equations, which brought forth his first essay—which occupied him even on the banks of the Nile—and an elaborate work on which was almost his last addition to science,—is of course one of less general interest.

(686.) Experiments—Style. His experimental abilities, as we have said, were not equal to his mathematical; and it is to be regretted that his schemes for several practical applications of theory seem to have been left imperfect. He invented a Thermometer of Contact, an instrument for determining the conductivity of bodies, which is but little known or used, and of which the theory was left incomplete. He also joined Oersted in experiments on Thermo-Electricity. He studied with great care the principles on which his theories were based, and seems throughout to have desired to leave no doubtful step in his reasonings, nor to make any tacit or unproved assumptions. His compositions are minutely clear. To them we might apply the remark attributed to Voltaire—"Whatever is obscure is not French." If there be obscurity, it is only due to the abstruseness of the subject, not to the manner of conveying it.

(687.) His death. Fourier succeeded Delambre as Secretary of the Mathematical Class of the French Academy of Sciences, and wrote several *Eloges*. He died no the 16th May 1830, generally respected.

(688.) Fourier's successors. We will here, in a few words, comment on the subsequent progress of the subject of the Conduction of Heat.

(689.) Poisson. Whilst Fourier's papers were still in the archives of the Institute, they were consulted by Poisson, who published solutions of several problems based on Fourier's principles, and coinciding in result with his. As the analysis used was somewhat different, the coincidence in so new a subject was not without importance. In 1835, the Theory of Heat of the same author appeared, based on the law of cooling, discovered by Dulong and Petit, which Poisson, with unaccountable yet characteristic rashness, chose to consider as applicable to the communication of heat from particle to particle, as well as to its dissipation from the surfaces of bodies. But the result was worthy of the looseness of the assumptions; the terms arising from the peculiarity of Dulong's law are mostly dispensed with as the investigation proceeds; and the whole work is to be regarded rather as a mathematical exercitation, than as a serious step in physics. Having elsewhere recorded a criticism on that part of Poisson's work which treats of the Heat of the Globe, I shall not dwell farther on its defects.[1]

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[1] See the next Section.

(690.) Professor Kelland's *Theory of Heat.*

Professor Kelland has published a work[2]—the only one intended for students—on this subject, and he has likewise made a valuable report to the British Association, on the best means of comparing the Mathematical Theory of Heat with Observation.[3] He has suggested, that the results of the Newtonian law of cooling may be used in combination with such an hypothesis as to the relation between quantities of heat and the temperature shown by an air thermometer, as will reconcile it with Dulong's law. But there is reason to think, that internal conductivity varies with temperature in the *reverse* manner of external cooling; in other words, that it diminishes as the absolute temperature increases.[4]

(691.) Case of bodies which do not conduct heat uniformly in all directions.

MM. Duhamel and Stokes have considered the propagation of heat in bodies which do not conduct it uniformly in all directions; and their investigations are very interesting in connexion with the beautiful observation of M. de Senarmont, that such is the case in crystallized bodies. It is easily shown in a plate of gypsum coated with a thin layer of wax, to a small part of which heat is applied.

§ 7. Dulong.—*The Law of Cooling.—Progress of the Science of Radiant Heat between Leslie's and Melloni's Discoveries; transmission of Radiant Heat through Glass.* Herschel; De la Roche; Professor Powell.—*Theory of Dew;* Wells.

(692.) Subject of radiant heat resumed.

The researches of Leslie on Radiant Heat, though very generally appreciated both at home and abroad, were not, on their publication, immediately repeated or extended. On some points they were seriously controverted. But the labours of most of his immediate contemporaries, of whose names we have given a few at the head of this section, were rather preparatory to the fuller developments of a later time—to be made with improved apparatus—than demonstrated discoveries. I make an exception, however, with regard to the experiments of Dulong and Petit on the laws of simple radiation and of the cooling of bodies by the contact of gases, not only because they established propositions quite new in an incontrovertible manner, but also because they introduced into this branch of science a mode of investigation so delicate and precise, and methods of reduction and of physical analysis so beautiful and convincing, as placed the whole science of Heat on a new footing. The main credit is due, we believe, to Dulong, who was one of the most estimable and accomplished philosophers of his time.

(693.) Dulong—an eminent chemist.

Pierre Louis Dulong was born in 1785, and showed precocious talents. He was admitted to the Polytechnic School at the age of 16, and rose through every grade of that celebrated institution until he became "Directeur des Etudes." It is superfluous to say that he was a good mathematician. He was also a most excellent chemist; and the honour of being discoverer of the most terrific of fulminating compounds (chloruret of azote) was purchased by the loss of one of his eyes. But his experiments on Heat are those by which he will be longest remembered. The most important series of these was devoted to a rigid examination of the amount of heat radiated under different circumstances, and of that dissipated by the contact of air.

(694.) Dulong and Petit correct the Newtonian law of cooling.

The law of Cooling.—It had been suggested by Newton, and tacitly admitted by nearly all writers on heat, including the most eminent, that simple radiation (or *pulsation*, in the language of Leslie) takes place in direct proportion to the excess of temperature of the hot body above the surrounding space. Martine, and particularly De la Roche, had indeed thrown doubt on the subject, and had rendered it probable that at high temperatures the velocity of cooling (which is proportional to the radiant energy) is considerably greater than Newton's law supposes. Dulong and Petit, however, first demonstrated this. They disengaged the experiment as far as possible from the influence of the contact of air, by using the most perfect exhaustion which the best air-pumps could produce; and it appeared very plainly from the result of observations made under successive degrees of rarefaction, that instead of there being the slightest appearance of radiation ceasing to take place when the vehicle of air was absent, the influence of the latter became less and less perceptible.

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[1] See Second Report on Meteorology, *Brit. Assoc. Reports*, 1840.

[2] *Theory of Heat.* Camb., 1837.

[3] *Brit. Assoc. Reports*, 1841.

[4] This at least is the result of an experimental investigation by myself on the conductivity of iron, executed on a principle which I believe to be new, but which I have not yet been able to publish. Mr Airy and Professor Kelland are each in possession of the outline of my method; and the result noted in the text was briefly announced by me in the *Reports of the British Association* for 1852. If my health permits, I shall resume and publish these experiments. I may here add, that I pointed out in 1833, from some experiments which I made at that time (*Proceedings of the Royal Society of Edinburgh*, vol. i. p. 5), that the metals range in the same order as conductors of Heat and of Electricity; and this law appears to be confirmed by more recent observations.

(695.) Their apparatus.

The principal apparatus of Dulong consisted of a balloon of thin copper about a foot in diameter, coated internally with lamp black, and placed in connection with an air-pump, so that any portion of atmospheric air could be extracted up to about $\frac{399}{400}$ of the whole, and any other gas could be introduced into it. The temperature of the balloon could be nicely regulated by introducing it entirely into a water trough. Into the centre of the balloon, thermometers of different sizes, or having different kinds of surface, could be introduced. The temperature of the balloon having been first regulated, the thermometer under experiment (being itself the radiating and cooling body) was heated nearly to the boiling point of mercury, and inserted in the balloon so as to occupy the centre of it. The exhaustion and other arrangements being made, the observations on the rate of cooling of the thermometer commenced when its temperature was as high as 250° or 300° centigrade, equivalent to 482° and 572° Fahrenheit.

(696.) Velocity of cooling not simply as the excess of heat.

With respect to simple radiation, or when the effect of air in the balloon is estimated as nothing, the inaccuracy of the Newtonian law was soon apparent. Whilst the excess of temperature of the cooling body above the envelope or balloon remained constant, and the absolute temperature of both was made to vary, the velocity of cooling, instead of being constant, increased rapidly with the temperature. Thus the excess of temperature being in every case 200° centigrade, and the temperature of the balloon being ... 0°, 20°, 40°, 60°, 80°, the rate of cooling was 7·4, 8·6, 10·0, 11·6, 13·4. The whole of an elaborate series of observations was beautifully and satisfactorily represented by a formula admitting of this simple physical interpretation, viz., that the cooling of the thermometer is the difference between the heat which it parts with *to* the envelope and the heat which it receives *from* the envelope; and that the heat thus parted with, either by the thermometer or the envelope, varies in a geometric ratio with its temperature.[1]

(697.) Effect of contact of air on the rate of cooling.

The effect of contact of a gas in cooling the thermometer is more complex. It is *independent of the texture of the surface*, as Leslie had already supposed. The cooling power of a gas is *proportional to a certain power of its elasticity, which varies for each;* it takes place more rapidly in hydrogen than in any other known gas, which was likewise discovered by Leslie. It also comes out rigorously, that *the ratio of the radiating power of different surfaces is the same at all temperatures.* This ratio for glass and silver is 5·707 : 1. Assuming this last principle, and also that the cooling due to the contact of air is independent of the surface, the law of cooling *in vacuo* may be deduced from the observed cooling of two thermometers suspended in air, and having glass and silvered surfaces respectively. Dulong and Petit found that, when they analyzed their experiments in this way, they obtained values for the radiation *in vacuo* almost absolutely coinciding with what direct experiment had already given. No more perfect criterion could be desired of the soundness of every link of the chain of experiment and induction.

(698.) Other memoirs of Dulong on the laws of heat.

We shall not analyze Dulong's other memoirs. They regarded matters in the science of Heat requiring the same skill in devising apparatus and in manipulation, the same caution in eluding errors, and the same just principles of calculation as in the investigations already specified. They did not, however, lead to the discovery of laws so striking and so general. They included the very delicate and difficult subject of the laws of the thermal expansion of bodies, particularly that of air and of mercury, which were applied to the theory of the thermometer, the very basis of all exact knowledge in the doctrine of heat. Another referred to the specific heat of the gases, an enquiry of the very greatest difficulty, in which we still find physicists disagreed. Dulong bethought himself of using Laplace's celebrated correction for the velocity of sound due to the heat developed during the compression of an elastic medium (art. 433), and proposed to deduce the heat thus developed, by a comparison of the observed and theoretical (Newtonian) velocity of sound, and thence to obtain the specific heat. The theoretical velocity is easily obtained from the density of a gas under a given pressure: the observed velocity was ingeniously found by sounding one and the same organ pipe with the different gases in succession, and ascertaining the pitch by the aid of Cagniard de Latour's *Sirène.* (441.)

Specific heat of gases.

(699.) On the elasticity of steam.

One of Dulong's latest, most elaborate, and most useful labours, was ascertaining the elasticity of high-pressure steam in terms of its temperature. These experiments were carried as far as 24 atmospheres of pressure. In the course of them the law of Mariotte and Boyle was verified up to the same limit. The condensation of air was found to be exactly proportional to the pressure. We shall return to the subject of these later experiments of Dulong in mentioning the still more recent ones of M. Regnault.

(700.) Character of Dulong.

Dulong was unfortunately lost to the world at the comparatively early age of 54. His was the peculiar merit of a well-balanced scientific mind. He felt the necessity of introducing into physics a degree of precision then almost unthought of. Coulomb had done something of the kind in other branches; but in Heat it was really new. It was speedily succeeded by a rapid advance of precision in almost every kind of delicate experimental research. Nowhere can the student of physics find a better model than in the celebrated memoir on the Law of Cooling, which, we may add, received, as a matter of course, from the Academy of Sciences, the prize in competition for which it had been composed.[1] It is only justice to the countrymen of Dulong to say that they retain the superiority in the deduction of numerical laws from observation, which Coulomb and he conspicuously exemplified. The industry of the Germans and of the English have indeed been great; but in this particular enquiry they have not equalled in address the members of the French Academy.

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[1] Thus symbolically expressed:— $V = m\left(a^{t+\theta} - a^{\theta}\right);$

where V is the "velocity of cooling," or depression of the thermometer in centigrade degrees in one minute, supposing it to continue constant for so long; θ is the temperature of the envelope; $t + \theta$, that of the thermometer; a is a constant independent of the size and surface of the cooling body, and which is $= 1·0077$; m is a constant depending on the dimensions and surface of the body.

(701.) In order to complete our sketch of the more important steps connecting the discoveries of Leslie with those of Melloni, we will now, going back a little in point of date, trace the origin of correct experiments on the immediate transmission and refraction of heat by solid substances.

(702.) Observations of Sir W. Herschel on the heat of the solar spectrum.

Sir William Herschel having found it requisite in the course of his arduous observations on the sun to devise means for preventing the intense heat of its rays from reaching the eye, was naturally led to observe the effect of different coloured glasses, and even of coloured liquids in this respect. He also placed thermometers in different parts of the spectrum formed by a prism, in order to discover which of the rays it was most important to exclude. The singular result at which he arrived was this, that the intensity of heat accompanying the light of the sun not only increases from the violet to the red end of the spectrum (as was already known), but is more intense quite beyond the red, and gradually diminishes in force for a long way farther. This result was keenly contested by Leslie, but was confirmed by Englefield and Davy. Berard admitted the existence of invisible heating rays from the sun, but yet found the maximum effect *within* the red. Seebeck, by numerous experiments, proved that the position of the *maximum* depended on the nature of the prism, being found even in the yellow ray when a prism of water is employed, whilst with flint glass it always occurs in the space beyond the red. The rationale of this curious result was first discovered by Melloni, whose labours will be detailed in another section; and it was shown to depend on the different degree of absorption exercised on the heat of the several rays of the spectrum by the differing material of the prisms.

(703.) Other experiments.

Herschel made a very great number of experiments on the transmission both of solar and fire-heat through different kinds of glass and other bodies. But they were rough trials, giving a sort of practical test of this quality, rather than admitting of accurate estimations of the quantities of transmitted heat. It was impossible, for instance, to infer from them the degree in which the warmth induced in the glass or other medium by the heat which it absorbed, tended to raise the indications of the thermometer beyond; although such an effect was manifest from the results of the experiments themselves. Hence it was open to an objector to deny the *direct* transmission of radiant heat through such bodies as glass, except in the cases of the sun and of brilliant combustion, when it cannot be doubted.

(704.) Important experiments of De la Roche on the transmission of radiant heat through glass.

Prevost had proved to his own satisfaction the immediate transmission of heat derived from bodies even when below the temperature of visible redness, by using thin screens of glass, and renewing them frequently before they could have absorbed much heat. Maycock obtained a similar result; but to De la Roche is due not only the establishment of this fact beyond any reasonable doubt, but also the discovery of certain laws of its operation which are inexplicable on any other supposition but that of immediate transmission. One of these laws, for instance, was this, that when a series of thin glasses are interposed between a source of heat and a thermometer, each successive glass transmits a larger proportion than the previous ones of the heat which falls upon it. De la Roche rightly accounted for this significant fact by assuming that heat is not homogeneous, and that the heat which has once passed through glass has lost the rays which glass most easily intercepts. He farther found that the susceptibility of heat to pass through glass increases rapidly with the temperature of its source. The experiments of De la Roche date from 1812.

(705.) Professor Powell.

The next step was made by Professor Powell of Oxford (1825). He showed that the *quality* of the heat transmitted by glass is not the same as that of the incident heat. This he proved by ascertaining the proportion of heat absorbed by a *black* relatively to a *white* surface. This proportion was invariably increased by the interposition of glass. Mr Powell concludes that heat consists of two kinds intimately mixed. That of which the absorption depends on the *colour* of the surface on which it falls, is usually luminous, and is most easily transmitted by glass. That kind of heat which is equally absorbed by black and white surfaces is totally devoid of light, and is sometimes considered as pure radiant heat.

(706.) Wells' theory of dew.

It will be sufficient here to refer to an interesting *Essay on Dew*, published by Dr Wells in 1815, in which he applies Leslie's experiments on the radiating power of different surfaces to account for the apparently capricious formation of dew in different situations,—establishing that it is moisture deposited from the lowest stratum of air upon surfaces cooled below the "dew-point," by their unrequited radiation of heat towards a clear sky. A slight wind, by continually restoring the equilibrium of temperature to the surface, prevents the deposition.

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[1] As the original paper of Dulong and Petit, in the Memoirs of the Institute, or the *Annales de Chimie*, is not always accessible, I may mention that it is translated almost or quite *in extenso* in Thomson's *Annals of Philosophy*, vol. xiii., and in Mr Lunn's excellent treatise on Heat in the *Encyclopædia Metropolitana*.

§ 8. Melloni.—*Recent History of Radiant Heat—Transmission and Refraction of Heat; Properties of Heat analogous to Colour.—Experiments in Great Britain on the Polarization and Double Refraction of Heat.*

(707.) Recent observations on radiant heat.

The length to which this chapter has already extended, must be my apology for bringing concisely to a conclusion what remains to be stated regarding the progress of the subject of radiant heat. With the exception of the excellent researches of De la Roche on the immediate transmission of radiant heat through glass (mentioned in the preceding Section), but which that ingenious philosopher did not live to extend and complete, little of importance was done between the researches of Leslie and those of Melloni, of which we are now to speak.

(708.) Melloni—the associate of Nobili.

Macedonio Melloni, a native of Parma in Italy, became associated as an experimenter, probably about the year 1828 or 1829, with Nobili, a skilful and ingenious physicist of Reggio (Modena). Nobili was well known by his experiments on galvanic Electricity and on Electro-Magnetism. He was also the great improver of Schweigger's Multiplier, rendering it an instrument of precision; and to him we owe the happy and ingenious application of Thermo-Electricity to the measurement of minute effects of heat.

(709.) The thermo-multiplier, an instrument of research.

The Thermo-Multiplier, a thermometer of extreme delicacy, though improved by Melloni, was (as has just been stated) the invention of Nobili. It consists of two portions, a sentient part and an indicating part. The first is composed of a number of short thin bars of antimony and bismuth, arranged like a square faggot, pairs of bars being soldered together in consecutive order at the opposite ends of the faggot, so as to form a single bent metallic conductor. If the junctions exposed at one end of the faggot are subjected to heat, and those at the other end kept cool, the effect will be a thermo-electric current of considerable intensity generated by the pile. This current is conveyed by means of two wires from the opposite ends of the system, which are connected with a delicate galvanometer which forms the *indicating* part of the apparatus. In practice, one end of the pile, armed with a conical reflector for concentrating the rays of heat, is exposed to a calorific source whose radiant effect is to be measured, whilst the other end is carefully screened from external influences. The deviations of the galvanometer needle indicate the heating effect as on the scale of a thermometer. The precautions required in the construction and use of the instrument, and in the interpretation of its results, are too numerous to be mentioned here.

(710.) Nobili, in conjunction with Melloni, applied the thermo-multiplier (amongst other experiments) to the proof of the instantaneous transmission of heat through glass and other solid and liquid bodies.

(711.) Melloni discovers the wonderful transparency of rock-salt for heat.

From 1831, this enquiry was conducted nearly exclusively by Melloni, who about that time settled first in Geneva and then in Paris, having been compelled, on political grounds, to quit Italy. His first and most important original memoir was presented to the Academy of Sciences early in 1833, and was received with marked coldness, if not incredulity, by that body. A few months later, the writer of these pages had an opportunity of seeing Melloni's experiments in Paris, and he made known their importance at the immediately succeeding meeting of the British Association at Cambridge. The Royal Society of London in no long time awarded their Rumford medal to Melloni, after which mark of foreign approbation, he first obtained a hearing from the Institute of France. The most considerable result at which he had then arrived was this: that rock-salt possesses a power unapproached by any other substance of transmitting heat of any temperature and from whatever source, with extremely little loss; and as a natural consequence of this, that heat wholly devoid of luminosity, such as that from boiling water, or even the heat of the hand, may be refracted by prisms and lenses of rock-salt exactly in the same manner as light is refracted by glass. The reality of these effects (which had excited the persevering scepticism of the Parisian *savans*) was demonstrated by a great number of most ingenious experiments, in which every possible source of error and confusion was avoided or allowed for.

(712.) Melloni even believed that the loss observed in passing heat of any temperature, high or low, through polished screens of rock-salt, was precisely the same; and, moreover, that it occurred entirely at the two surfaces by partial reflection, so that the solid medium was *absolutely transparent* for every kind of heat. It is certain that the loss is in every case small; but this almost paradoxical conclusion has not been completely confirmed by those who have repeated his experiments. The important and unexpected discovery of the nearly complete transparency of rock-salt for heat, enables us to construct complex *thermotic* apparatus for refracting and concentrating it, analogous to those of glass which are used in optics.

(713.) The next point clearly made out by Melloni, was the *specific action* of different bodies in sifting the

The specific action of different substances on the rays of heat.—Coloration of heat.

rays of heat they transmit, stopping altogether certain kinds or qualities of heat and transmitting others. Substances, in general, transmit most readily the heat radiated by surfaces having a high temperature; this had already been shown to be true in the case of glass by De la Roche. That experimenter had also demonstrated (as we have seen in Art. 704) that successive plates of glass intercept a constantly decreasing percentage of the heat incident upon them. This may be explained by supposing radiant heat to be, like the light of the sun or of a flame, heterogeneous, containing rays of different qualities, some of which are easily transmitted and others are wholly stopped by glass. And if we pursue the analogy with respect to other substances, we may imagine (for the sake of illustration) heat to be *coloured*, and that different media, though equally transparent and colourless as regards light—such as glass, rock-crystal, and ice—exercise a specific action on the rays of heat, each transmitting certain portions of the heat and stopping others. Rock-salt alone (according to Melloni) is absolutely *colourless* with respect to heat, transmitting all its varieties with uniform facility. Thus equally thick and equally clear plates of salt, glass, and alum, transmit, out of 100 rays of heat from different sources the following proportions:—

	Heat from a bright flame.	Heat from incandescent Platinum.	Heat from a surface at 700° Fahr.	Heat at 212°
Rock-salt	92	92	92	92
Plate-glass	39	24	6	0
Alum	9	2	0	0

(714.) Refrangibility of Heat.

Let, however, heat which has been sifted by a plate of alum fall on another similar plate, then instead of 9 per cent., 90 per cent. will be transmitted. On the other hand, if we unite two plates of opposite transmissive qualities, as alum and *green* glass, the combination is almost absolutely opake, just as a combination of two coloured glasses giving different pure tints (say red and green) would be opake for light. The working out of this beautiful enquiry is entirely due to Melloni; and he has published a separate work on the "Coloration of Heat."[1] He also rendered it probable that the rays most easily absorbed by glass and bodies generally are the *least* refrangible; and this has been made certain by direct experiments by the author of this Dissertation, who, by a peculiar method, founded on the Total Reflection of heat within a prism of rock-salt, has obtained the following Indices of Refraction:—

Heat from a lamp, mean refractive index	1·531
Do. passed through glass	1·547
Do. do. alum	1·558
Mean luminous ray	1·562

(715.) Explanation of point of maximum heat in the spectrum.

Melloni ingeniously applied the facts previously mentioned to explain the variable position of the hottest part of the spectrum, as observed by Sir William Herschel and others. It depends on the nature of the prism employed. In a prism of rock-salt, the hottest part of the spectrum is as far *beyond* the extreme visible red, as the interval between that red and the yellow ray in an opposite direction.

(716.) Death of Melloni.

Through the intervention of Arago and of Baron Humboldt, Melloni ultimately obtained permission to return to Italy and to reside at Naples, where he spent his latter years. He ceased, however, to prosecute his researches on radiant heat with the same energy, under circumstances of ease and comparative affluence, that he had done in the period of distress and obscurity. Nevertheless, several original papers were written by him at this period, as well as the condensed account of his earlier researches on the Coloration of Heat, of which only the first volume appeared. Melloni died of cholera at Portici, in August 1854, aged 53.

(717.) Early attempts to polarize radiant heat—Berard.

The analogy of Radiant Heat to light, strikingly established by Melloni, with respect to the diversified refrangibility and other qualities of the various radiations emitted by one or different sources, suggests an enquiry as to the intimate nature of these two agencies. No answer is likely to be so conclusive as an appeal to the test of *Polarization*, which, in the case of light, has been so remarkably explained by the theory of the transverse undulations of a medium. Some years before any of Melloni's papers appeared,—indeed, before he had entered on the investigation just noticed,—the writer of the present Dissertation had attempted, by means of common thermometers, to test the polarizability of heat. The trial was not a new one; but, except in the case of the heat of the solar rays, the results seemed to be inconclusive, or were even wholly negative. Berard had, indeed, not long after the discovery by Malus of luminous polarization by reflection, repeated (in 1812) that experiment with sun-heat, and also with the heat emanating from terrestrial sources; and as he believed with success.[2] I have ventured to call his experiments inconclusive, because others besides myself vainly endeavoured to repeat them. Professor Powell failed with ordinary thermometers, and at a later period Nobili announced a decidedly negative result, obtained with the thermo-multiplier. Simple radiant heat, he affirmed, is not polarizable by reflection.[3]

(718.) Experiments by the present writer.

I have just referred to my own early experiments on the subject (which were likewise inconclusive), in order to explain that it was natural, on hearing of the application of the thermo-multiplier to measure radiant heat, that I should wish to repeat them with the new instrument. This I did in 1834. I first succeeded in proving the polarization of heat by tourmaline (which Melloni had announced did not take place);[1] next, by transmission through a bundle of very thin mica plates, inclined to the transmitted ray; and afterwards by reflection from the multiplied surfaces of a pile of thin mica plates placed at the polarizing angle.[2] I next succeeded in showing that polarized heat is subject to the same modifications which doubly refracting crystallized bodies impress upon light, by suffering a beam of heat (even when quite obscure), after being polarized by transmission, to pass through

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[1] *La Thermochrose, ou la Coloration Calorifique.* Naples, 1850.

[2] *Memoires d'Arceuil,* vol. iii., p. 5.

[3] *Bibliothèque Universelle,* Sept. 1834.

Depolarization of heat.

a depolarizing plate of mica, the heat traversing a second mica bundle before it was received on the pile. As the plate of mica used for depolarization was made to rotate *in its own plane*, the amount of heat shown by the galvanometer was found to fluctuate just as the amount of light received by the eye under similar circumstances would have done. This experiment which, with the others just mentioned, was soon repeated and confirmed by other observers, still remains the only one proving the double refraction of heat unaccompanied by light; and though somewhat indirect, it will hardly be regarded by competent judges as otherwise than conclusive. Iceland spar and other doubly-refracting substances, absorb invisible heat too rapidly to be used for effecting *directly* the separation of the rays, which requires a very considerable thickness of the crystal.

Circular. polarization.

I also succeeded in repeating Fresnel's experiment of producing circular polarization by two internal reflections. The substance used was of course rock-salt.[3]

§ 9. M. REGNAULT.—*Numerical Laws of Expansion by Heat;* Rudberg.—*Vaporization;* Dulong.—*Latent Heat; Hygrometry.*

(719.) M. Regnault.

THE limits of this Essay will not permit me to do more than allude in very general terms to the meritorious services of M. HENRI-VICTOR REGNAULT in the science of heat. In the seventh section of this chapter I have mentioned his name in connection with that of Dulong, whose researches he has prosecuted, and whose position in the Collège de France he now fills.

(720.) Skill of French experimenters.

The attention of M. Regnault has been devoted chiefly to heat in its combinations with matter—to dilatation and vaporization. I have already said, in speaking of Dulong, that, in point of numerical precision in the results of experimental physics, the French are unrivalled. The talent which they have shown in the construction of apparatus, skill in its use, and patience in deducing results with due attention to every numerical correction, have not been equalled either in England or Germany, much less elsewhere.

(721.)

Coefficient of expansion of gases and mercury; Rudberg —Dulong.

We must, however, note that doubts were first thrown upon the accuracy of Gay-Lussac's coefficient of the expansion of the gases (0·375 of the volume at 32° for the expansion between 32° and 212° Fahrenheit) by Rudberg a Swedish philosopher, who determined a new coefficient (0·3645). M. Regnault finds for air of the ordinary density a coefficient nearly the same as that of Rudberg, but differing slightly for the same fluid under differing pressures, and also for the various gases.[4] The expansibility of all of these fluids appears to tend to the same limiting value when they are sufficiently attenuated. As a preliminary to these experiments, the expansion of mercury was ascertained by its hydrostatic equilibrium at different temperatures, as had already been done by Dulong, and with almost coincident results. The dilatation of mercury was used to ascertain that of the glass vessels employed.

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The irregularity of the dilatation of glass is one of

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[1] *Annales de Chimie*, tom. lv. (1833).

[2] I was led to polarize heat by transmission through mica films from having observed the extraordinary permeability of those films to radiant heat, and from the facility of adapting them to tubes applied to the pile. The idea of using bundles of mica for *reflecting* heat did not occur to me until some time after. But I cannot here omit mentioning a circumstance of which I only became aware some years after the publication of my researches. In arranging my correspondence, I found some letters from Sir David Brewster, with whom I had communicated as to the best means of polarizing heat, during my earliest and unsuccessful attempts with common thermometers. In one of these letters he recommends, among other methods, the reflection of radiant heat from mica bundles. This suggestion was not put in practice; for, owing to change of residence and other circumstances, my attention was diverted to other subjects, and only recalled, after a lapse of some years (as stated in the text), to the polarization of heat, by the invention of the Thermomultiplier. Nor was Sir D. Brewster's suggestion recollected by me until I accidentally met with it (after another long interval), in the manner which I have just stated. I am glad to have an opportunity of acknowledging the friendly assistance and encouragement in all matters of science which at an early age I received from him when I was an obscure, though ardent student, and when he was my only scientific adviser.

[3] I have not thought it proper to go into farther details concerning my own experiments on radiant heat. Those who desire more information will find it in Professor Powell's Second Report on Radiant Heat, in the *Brit. Assoc. Reports for* 1840. But I may here state, that M. Melloni's first experiments on polarization were made with mica piles, furnished to him by myself in 1835.

[4] M. Regnault's experiments were published in 1841. Professor Magnus of Berlin was at the same time engaged on similar experiments, and with nearly coincident results. The following table contains the summary of all these experiments :—

Co-efficients of expansion of gases.

Dalton's coefficient	0·391
Gay-Lussac's coefficient	0·375
Rudberg's coefficient	0·3645
M. Regnault's coefficient (from the expansion observed under a constant pressure)	0·367
M. Regnault's coefficient (from the elasticity observed under a constant volume)	0·3665
M. Magnus' coefficient (from the elasticity observed under a constant volume)	0·3665

Dalton's experiments were made between 55° and 212°, and after allowing for the expansion of glass, he obtains for the relative volumes of air at those temperatures 1000 and 1325, giving $\frac{1}{483}$ of the volume at 55° for 1° Fahr., or $\frac{1}{480}$ of the volume at 32°, which agrees with the co-efficient given above. See *Manchester Memoirs*, vol. v., p. 598–9.

Irregular dilatation of glass. the great difficulties not only of these enquiries, but generally, in constructing comparable thermometers. It varies so much with the composition of the glass as to leave a serious amount of uncertainty in the measure of temperatures above that of boiling water. M. Regnault has had the perseverance himself to graduate the thermometers which he uses.

(723.) Dulong and M. Regnault on the elasticity of steam. These enquiries were in some measure introductory to the determination of the elasticities of steam at different temperatures, which had been already ascertained with so much care by Dulong (nominally in conjunction with Arago and other academicians), as to leave little need for their repetition, except on the ground of the uncertainty of the indications at high temperatures of the thermometers which they used. All M. Regnault's results are most carefully expressed in terms of temperatures measured on an air thermometer corrected for the expansion of glass. They agree well with those previously ascertained by Dulong.

(724.) M. Regnault on latent heat. In connection with this subject, the important law of the latent heat of steam at different temperatures has been correctly ascertained for the first time by M. Regnault. Watt maintained that the sum of the sensible and latent heats of steam is constant at all temperatures: Southern and others, on the contrary, believed that the latent heat has a constant value, whatever be the temperature of vaporization. M. Regnault shows that the true law is intermediate. *The latent heat diminishes as the sensible heat of steam increases, but in a slower proportion.*

(725.) Law of Mariotte and Boyle. Our author also followed the steps of his predecessor Dulong in verifying the law of Mariotte and Boyle on the compressibility of the gases. He found it to be indeed very approximately true, yet not absolutely so for any gas. For atmospheric air and for most other gases the compression increases rather faster than the strict proportionality to the pressures would assign. In hydrogen gas the contrary is the case. This result, together with that on the dilatation of different gases, shows (if fully confirmed hereafter) that mere simplicity or uniformity of result is not by any means a sure ground of induction as to a law of nature. That simplicity often appears to be predicable only of some abstract condition of matter which we may assign or imagine, but which we rarely if ever find realized amongst the bodies around us.

(726.) The preceding investigations, the result of an amount of minute and assiduous labour almost fearful to contemplate, are to be found collected in the 21st volume of the Memoirs of the French Academy of Sciences, which they entirely occupy.

(727.) M. Regnault on Specific Heat and Hygrometry. M. Regnault has elsewhere published analogous researches on the Specific Heat of a great variety of substances, and on the theory and practice of Hygrometry, both of which are highly interesting and important, but which I have not here space to analyze. He is also favourably known as the author of an excellent treatise on chemistry, and in fact sits in the Institute as a member of the Chemical Section. He now directs the manufactory of porcelain at Sevres; and being still in the prime of life, much may yet be hoped from his devotion to science.

CHAPTER VII.

ELECTRICITY—MAGNETISM—ELECTRO-MAGNETISM.

§ 1.—Galvani.—*Discovery of Galvanism; Proper Animal Electricity.—The subject revived by* Nobili.—MM. Matteucci *and* Du Bois Reymond.

(728.) Galvani. There are few discoverers in science whose position it is more difficult to assign with accuracy than Galvani. Attaining at first, by a curious observation patiently reflected on and carefully repeated in detail, to the rank of the founder of a new science, he was so far outstripped in its applications, that his merit was soon in a measure overlooked, and his unquestionable discoveries ascribed to capricious accident.

(729.) His position as a discoverer difficult to estimate. We find that a concurrence of circumstances contributed to this result. Galvani was advanced in years, and, it would appear, somewhat exhausted in constitution, when he made his famous observation on muscular contractions. He was an anatomist, far more than either a chemist or physicist;—no blame, surely, is to be attributed to him on that account! His discovery was chiefly interesting in his eyes, as illustrating the laws of sensation and the source of nervous irritability. It was calculated to throw great light on these most abstruse enquiries. Groping to find the thread which should reveal to him that labyrinth, is it surprising that he devoted himself exclusively to those effects which gave him a real promise of success?—a promise held out still by the same facts—still the envied goal of physiologists—yet how little realized by the unremitting labours of two subsequent generations!

(730.) Contrast of Galvani and Volta. Again, the almost irresistible temptation of converting successful philosophers into heroes, at the expense of their contemporaries, added to a less pardonable wish to relieve the tedium of scientific discussion, by the introduction of a lively, though questionable anecdote, has induced the eulogists of Volta to exalt his unqestionable claims by the depreciation of those of his less widely known and less fortunate countryman, Galvani. Their contrasts in character and circumstances were sufficiently marked. Galvani was a professional anatomist and physiologist; Volta a physicist. Galvani was little known, and had probably travelled little beyond the province in which he resided; Volta was personally and advantageously known in Paris and London. Galvani, soon after his discovery, fell into undeserved political disgrace, which undermined his health; Volta lived to an advanced age, his experiments and discoveries rewarded by every honour which not only academic authority could bestow, but which the almost universal sway of Napoleon could render to his genius. Galvani died prematurely, and whilst his best observations were contested; Volta survived to nearly the latest term of human life, having witnessed the fruits of his great invention in the splendid discoveries of Davy and Oersted.

(731.) The biographical particulars of Galvani's life may be passed over in a few words. The history of his discoveries has been recently materially enlarged and corrected, by the researches of the Academy of Bologna to which he belonged, and especially by those of Professor Gherardi; it forms, together with his collected writings, a ponderous quarto volume.[1] The diffuseness of the commentary, and that of Galvani's writings also, is a defect in this compilation, which tends to weaken the unquestionable force of the evidence in his favour.

(732.) Galvani's first experiments on the Nervous System,

LUIGI GALVANI was born in 1737, and was promoted in 1762 to the chair of anatomy at Bologna, his native place, the seat of a most celebrated university. He studied and taught his science with great success, and published several memoirs. Probably he would have become still more widely known, but that he was anticipated in some of his observations (particularly on the organ of hearing) by the celebrated Scarpa; in consequence of which, Galvani, with his customary modesty, suppressed what had already become known through that able anatomist. As early at least as 1780 (as we learn from the researches of Gherardi, and the MSS. of Galvani himself), he made experiments on muscular contractions taking place by electric influence from the electrical machine, the electrophorus, and the Leyden phial.[2] The experiments were made on *frogs* in particular. This was ten years antecedent to the commonly alleged casual discovery of galvanism. The experiments were continued in 1781 and 1782, when he drew up a paper (not published) "On the Nervous Force and its relation to Electricity."[3] In 1786 he pursued the enquiry, with the aid of his nephew Camillo Galvani; and the effect of thunder-storms in occasioning muscular contractions in the frog (which he had previously noticed), was farther studied. He then designated the prepared frog as "the most delicate electrometer yet discovered."[4] But this year was also the one of his real discovery, namely, that muscular contractions are sometimes occasioned by causes remote from any then known to be connected with electricity. Camillo Galvani, pursuing his uncle's experiments on Atmospheric Electricity, had prepared some frogs, by dividing them about the middle, and detaching a portion of the lumbar nerves from the integuments, leaving them in contact with a portion of the vertebral column which was then suspended by an iron hook. These prepared frogs were lying horizontally on the top of an iron rail of a balcony on the third floor of Galvani's house, where he was in the habit of observing the effects of atmospheric electricity. The nephew noticed that when the hook or the vertebræ were pressed on the rail by the finger or otherwise, muscular contractions ensued, which he pointed out to his uncle, who lost no time in repeating the observation, which seems to have been made early in September 1786.[5] His experiments in this and the following month are detailed, with the exact dates still preserved, with this remarkable title in Galvani's hand-writing, — *Esperimenti circa l'Eletricità dei Metalli;* and the results are formally drawn up in a Latin Dissertation of 62 pages, bearing date 30th October 1786, forming the substance of the most important section of his *Commentary on the Electric Forces*, &c., published five years later, but differing from it in some important particulars.[6] Thus it appears distinctly, that one metal alone —iron—was used in producing the convulsion;[7] whilst in the printed *Commentary*, the hooks are said to be of brass or of copper. The explanation is, that Galvani having become aware of the superior efficacy of unlike metals in contact, described the experiment, not as it was *first* made, but as it *might* be made with greater certainty. Yet, singularly enough, this Dissertation is entitled,—*De animali Electricitate;* showing, that in the short space of a few weeks, he had abandoned his earlier notion of the *metals* being the source of the electricity, and ascribed the effects to the proper electricity of the nerves and muscles.

and on electricity in connection with it.

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[1] *Opere edite ed inedite del professore Luigi Galvani, raccolte e pubblicate per cura dell' Accademia delle Scienze dell' Instituto di Bologna.* Bologna, 1841. The copy which I use belongs to the Royal Society of Edinburgh.

[2] *Rapporto*, &c., p. 11 (in the work above cited).

[3] Ib. p. 18.

[4] Ib. p. 30. The expression is remarkable, because Volta is often regarded as the first who considered the frog in the aspect of a *mere* electroscope.

[5] *Rapporto*, pp. 33, 36.

[6] Ib. p. 35, 36. It were to be desired that this MS. were published in full.

[7] The passage from the MS. is conclusive,—"Ranas itaque consueto more paratas *uncino ferreo* earum spinali medulla perforata atque appensa, Septembris initio [1786] die vesperascente supra parapetto horizontaliter collocavimus. Uncinus *ferream laminam* (namely, the top of the iron parapet or rail) tangebat; en motus in rana spontanei, varii, haud infrequentes! Si digito uncinulum adversus ferream superficiem premeretur, quiescentes excitabantur et toties ferme quoties hujusmodi pressio adhiberetur."—*Rapporto*, p. 36.

(733.) Of these two very opposite aspects of this remarkable experiment, it might have been reasonably enough anticipated, that one should be wholly erroneous. This, however, is not the case. Galvani was justified in *both* his inferences, although he unquestionably believed that only one could be true. As a physiological anatomist, he not unnaturally adhered finally to the opinion of vital or animal electricity being the cause of the phenomenon which he had observed. Volta, on the other hand, already an experienced natural philosopher, though for a short time an entire convert to Galvani's published opinions, maintained the contact of metals, unlike either in kind or in their mechanical condition, to be the source of the nervous commotion; and whilst he was enabled to support his opinion by very striking experiments, its popularity was not unjustly perhaps exalted to the highest pitch by the happy application which he made of it, to the construction of that wonderful instrument, the voltaic battery, which effectually withdrew attention for a time from the comparatively feeble and obscure effects of the electric power residing in the animal tissues.

(734.) The proper electricity of the frog.

The historian of science, well aware how far the intrinsic importance of discoveries is from depending upon the mere magnitude of their effects, and how often the philosopher, dazzled by the splendour of a new truth, overlooks some minute concomitant phenomenon which hereafter may rival or eclipse its splendour,—readily recognises the perseverance with which Galvani maintained his theory of animal electricity as a part of the true philosophical character, and therefore as enhancing his reputation. The metallic arc which, by connecting the muscular part of the limb with the root of the lumbar nerve, occasioned the convulsion, was to be regarded, on his theory, as merely establishing equilibrium between those parts to which the vital principle had communicated an electric tension similar to that which subsists on the opposite surfaces of a charged plate or Leyden jar. Galvani gradually disembarassed his experiments from the suspicious presence of metals altogether. Taking the prepared hind-limb of a frog, with the connected nerve entering the spine, he found that when the latter was suffered simply to touch the bare surface of any muscular part, and without the intervention of metal or any other conductor, a spasm of the limb immediately occurred.[1] This important experiment was repeated and varied in 1795, by the celebrated Baron Alexander von Humboldt, who published a paper on the subject in *Gren's Journal*, fully confirming Galvani's conclusions. Volta, on the other hand, admitting the facts, strove to explain them on the supposition, that they were due, like other electric currents, merely to the heterogeneous nature of two solid bodies, the muscle and the nerve brought into opposition, and moistened by a conducting liquid. Experiments instituted after a lapse of 30 years, with the aid of new instruments, and vastly increased knowledge of electric manifestations, have conclusively demonstrated the accuracy in this respect of Galvani's reasoning in preference to Volta's.

Confirmed by Baron A. von Humboldt.

(735.) Gradual progress of Galvani's views.

The publication of the results already noticed did not take place till 1791 in his celebrated paper in the *Bolognese Transactions*. The statement popularly made by almost every writer (and which may be traced to Alibert, one of the earliest historians of the subject, but whose authority seems to be of little weight), is that the discovery of Galvanism was made in 1790, in Madame Galvani's kitchen, where a frog soup was being prepared for that lady's repast, she being at the time in delicate health. The absurdity of the invention is evident from the history which we have given, founded on unquestionable documents. The memoir of 1791 was the *resumé* of elaborate experiments continued with (apparently) little interruption for *eleven* years; and the most interesting results had been digested in a Latin tract *five* years before. All this shows at once great patience and intelligence on the part of Galvani, who, perceiving the difficulty and also the probable importance of the subject (in a physiological view)—oscillating perhaps in some measure between the two very opposite opinions regarding the source of muscular excitement which we have seen that he almost simultaneously held,—postponed for so long a time the publication of a discovery which he must have been sure would confer upon him a great reputation. By the time of his publication his views had become fixed in favour of *animal* electricity; and he defended it in several succeeding memoirs.

(736.) His death.

The unjust deposition of Galvani from his chair on political grounds affected seriously his health and energies. Perhaps his latest experiments were on the Electricity of the Torpedo. He died 4th December 1798, aged only 61—happy perhaps in not having witnessed the discovery of the Pile, which, by its astonishing results, was to throw into the shade Galvani's more intricate and difficult studies.

(737.) His distinguished merit.

To appreciate justly Galvani's place in scientific history, we must recollect three circumstances which have often been overlooked,—*First*, that his discoveries were the result of patient, ingenious, and protracted research, not of a casual observation exciting ignorant surprise. *Secondly*, That however deficient was Galvani's theory of animal electricity to explain all, or even the most conspicuous facts witnessed by him, it was a real discovery which has been confirmed by the latest and most scrupulous researches, and of a physiological importance which can hardly be overrated. *Thirdly*, Galvani's *Commentary* was received at the time with enthusiasm, not only from the importance of the facts which it contained, but from the ability shown by the author in discussing them. There was no part of Europe in which Galvani's observations were not held to bear out his theory; and the warmest eulogy of them is to be found in the writings of Volta himself, who soon advocated a different explanation. Volta calls animal electricity "a great and luminous discovery which forms an epoch in the annals of physical and medical science," and as "proved to demonstration (*ad evidenza*) by many experiments well contrived and accurately executed."[1] Had there been as little novelty as has sometimes been alleged in Galvani's observations, they would not have been heard of at once, and repeated in every civilized country, nor have given birth to a new and splendid science. Nothing then in progress, either in the hands of Volta or of any one else, gave the slightest clue to the invention of the Pile, which, but for Galvani, might have been yet undiscovered.

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[1] The earliest notice of this result is found in one of Galvani's autograph MSS., which appears certainly to date from 1786. *Rapporto*, p. 48, § 18.

(738.) Revival of experiments on animal electricity—Nobili.

Revival of Experiments on Animal Electricity.—The grand discovery of Oersted, which gave a fresh impulse to so many branches of science, revived likewise the subject of the proper electricity of the animal tissues, which had been well-nigh forgotten since the death of its discoverer Galvani. Twenty-nine years later, in 1827, Nobili of Florence demonstrated the existence of what has been termed "The current of the frog." We have seen that a momentary spasm is produced when a circuit is completed, including the muscle and nerve of the recently dead animal. But by the aid of that admirable instrument the Galvanometer, Nobili succeeded in showing that a continuous current of positive electricity constantly passes from the feet to the head of the frog. This he detected by placing the feet of the animal in connection with one end of the galvanometer wire, and its spine with the other (the whole being properly insulated), when the needle of the instrument was permanently deflected to the amount of 5° or more—indicating the passage of a stream of electricity in the direction already mentioned, which continued for several hours after death. Strange to say, Nobili misapprehended the nature of the phenomenon, ascribing it to Thermo-Electricity, though he ought to have been undeceived by the singular intensity of the animal current, which, feeble as it is, can force its way along thousands of feet, or even some miles of fine wire.[2]

(739.) MM. Matteucci and Du Bois Reymond.

These experiments were renewed in 1837 by M. Matteucci of Pisa, who has the merit of reviving the original and correct opinion of Galvani as to the vital source of this electricity. To his researches, and the still later ones of Dr Du Bois Reymond of Berlin, we owe the knowledge of most of the facts as yet ascertained in this most difficult and obscure branch of enquiry, where the sources of error are so numerous as only to be eluded by consummate skill on the part of the experimenter. It appears to be established that the vital electricity exists both in the muscles and in the nerves of many, probably of all animals when living or recently dead; that therefore the frog current of Nobili is only a single case of the general muscular current, and that the latter arises from the electro-motive action of even the minutest fibres of which a muscle is composed—the general law being (according to Dr Du Bois Reymond) that positive electricity moves from the transverse section to the longitudinal section of a muscle or a nerve, or any portion of either. Finally, the last-named writer has shown, to the satisfaction of many eminent men who have witnessed his experiments, that powerful muscular contraction, whether induced by stimuli or the result of volition, tends to diminish the force of the natural muscular current. This he demonstrated first on the frog poisoned by strychnine, but afterwards on the muscles of his own arm, in which by voluntary contraction he could diminish at will the force of the natural current, which in the state of rest is directed from the shoulder to the hand.

§ 2. VOLTA.—*Progress of Discovery in Common and Atmospheric Electricity—The Electro-motive Theory—Voltaic Pile—Chemical Analogies and Decomposition*—Fabbroni; Nicholson and Carlisle.

(740.) Volta.

VOLTA was the first among philosophers whose career lay solely in the study of electricity. Franklin and Æpinus, Beccaria and Wilke, Cavendish and Coulomb, gave it only a share of their attention; but Volta was from boyhood exclusively an electrician. Such devotion deserved success, and he achieved it. He was already famous, and an honorary fellow of the Royal Society, long before his principal discovery of the Pile. A review of his career may therefore be conveniently divided into two parts—what concerns ordinary and atmospheric Electricity; and the new doctrine of Galvanism and the Electro-motive force.

(741.) His early experiments—his Electrophorus and Condenser.

I. ALESSANDRO VOLTA was born at Como, of a noble family, in 1745. His first paper on Electricity was addressed to Beccaria at the age of eighteen. But it was not till 1775[3] that he published a description of the *Electrophorus*, an ingenious instrument in which a conducting body becomes electrified an indefinite number of times in succession by being brought near to an excited cake of pitch and resin. This charge is received by *induction* merely; and as it expends none of the electricity connected with the pitch, the successive charges are precisely equal, a circumstance which enabled Volta very simply to give a numerical value to the amounts of electricity used in his experiments, as they were given by one, two, or more contacts with the electrophorus. The *Condenser*, an ingenious and useful instrument for accumulating small charges of electricity until they attain a measurable amount, or cause divergence in the electrometer, was described by Volta in 1782 in the *Transactions of the Royal Society*, its construction having occurred to him in following out the idea of the electrophorus. This instrument was ultimately of essential service in establishing his theory of Electro-motion. The theory of both the electrophorus and condenser had been indicated by Æpinus some time before Volta constructed them; but he did not apply them in the practical way which Volta did to the improvement of his science. Volta being, besides, unquestionably ignorant of Æpinus's labours, has been generally and justly regarded as the real inventor. Though both of these instruments depend on the principle of induced electricity, Volta never appears to have possessed correct views on that subject, but throughout his writings speaks of electrical atmospheres, and uses other phrases of the old school of electricians, showing a certain vagueness in his conception which a study of the writings of his able contemporaries, Æpinus and Coulomb, would have dissipated.

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[1] *Opere del Volta*, ii., p. 13, 14.

[2] The galvanometer of Du Bois Reymond contains 3·17 English miles of wire, in 24,160 coils.

[3] See the letter to Priestley in the First volume of Volta's *Works*.

(742.) Volta's Straw Electrometer.

But Volta's tact was unconnected with any tinge of mathematical reasoning: his experimental ability, his caution, and his persevering devotion to one subject, enabled him, however, to advance science in a different way. Even the simple Straw Electrometer which he generally used, was tested by him with such skill and care as to lead to correct results in the measurement of small quantities of electricity. M. Biot has indeed criticised his preference for so rude an instrument, which depends, mathematically considered, upon repulsions of a very complicated character; but as Volta carefully tested its comparability up to 30° of divergence, and found it proportional to the force, there is no doubt that he was justified in relying on its use; and Arago, in opposition to his colleague, maintains that Volta's essay on the Straw Electrometer is one of the best examples of experimental research which can be put into the student's hands. This instrument is described in the first of a series of letters to Lichtenberg collected in the first volume of his works; the subject of these letters being the Electricity of the Atmosphere.

(743.) Atmospheric electricity.

The important experiments of Dalibard and Franklin, repeated with fatal consequences by Richmann, had demonstrated the perfect resemblance or rather identity of lightning and electricity. Lemonnier discovered the fact of electricity being manifested when no thunderstorm threatened, and even when the sky was cloudless, and that it was subject to diurnal variations of intensity. Beccaria farther ascertained that with a clear atmosphere the electricity of the air is always *positive*. De Saussure, Deluc, and Volta continued the interesting enquiry. The first, availing himself of the known action of points to draw off electricity, connected his electrometer with a pointed rod two or three feet in length. Volta substituted for this the flame of a lamp producing a heated current of air, which has a wonderful power of drawing off electricity; and he suggested the employment of large fires during thunderstorms in preference to metallic conductors. Volta hesitates not to ascribe to the worshippers of *Jupiter Tonans* the secret intention to draw off the electricity of heaven by the action of the flames on the altar.[1] Arago has ingeniously suggested that a statistical enquiry as to the frequency of thunderstorms in the neighbourhood of extensive iron-smelting furnaces might test the value of this safeguard. The straw electrometer which Volta connected with his apparatus was capable (by a gradation of instruments of greater or less delicacy) of measuring numerically the force of charges from 1000 to 2000 units.

(744.) Due to evaporation.

That the chief source of atmospheric electricity is evaporation appears first to have occurred to Volta, and to have been first demonstrated by experiments made either with him or by his suggestion, at Paris in 1780, by Lavoisier and Laplace. The history is given by Volta himself in a paper in the *Philosophical Transactions* for 1782. When water is thrown upon an insulated heated body so that evaporation takes place, or when hot coals are thrown into an insulated vessel of water, the hot body is usually found to be electrified negatively. Volta has very candidly stated the inversions of effect which occasionally occur, and which still throw some doubt upon the precise significance of this very important experiment. Later experimenters have thought that absolutely *pure* water developes no electricity: this, however, will not affect the validity of the explanation of the origin of atmospheric electricity. To prevent misapprehension it may be observed that the astonishing developement of electricity from high-pressure steam escaping through a small aperture, as lately observed by Mr Armstrong, appears, from the experiments of Dr Faraday, to depend on an entirely different cause. Of Volta's electrical theory of Hail we cannot now stop to speak.

(745.) Volta's Eudiometer

Volta, who understood chemistry and who always took a peculiar interest in the inflammable gases, contrived the Eudiometer which is often erroneously called Cavendish's, having been frequently used by that philosopher. The amount of oxygen in the air is tested by mixing the latter in known proportions with hydrogen in a close vessel through which an electric spark can be passed. Detonation takes place, and the quantity of gas which has vanished (by conversion into water) measures the amount of oxygen which has combined with hydrogen in the experiment. It was for a long period employed as by far the best means of testing the purity of air.

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[1] *Opere*, vol. i., part 2., p. 205. Volta's contrivance dates from the beginning of 1787. Bennett imagined it independently.

(746.) Practical character of Volta's inventions.

All the preceding labours of Volta (and I do not intend to touch on any minor ones) have evidently an intensely practical character. His aim throughout was to improve the instrumental means of detecting and measuring electricity, and to detect and measure it as it occurred in practice, rather than to form theories of its nature.[1] Even the discovery of galvanism, which vividly excited his interest, only partially diverted him from his scientific destiny. Volta will indeed be always remembered as the author of the plausible theory of electro-motion, and as having corrected the too exclusive doctrine of Galvani concerning the sources of electric excitement; but his real claim to immortality is the invention of the Pile. To this part of the history we therefore proceed.

(747.) History of the Pile—Volta's early papers on galvanism.

II. When Galvani announced his discoveries in the *Bolognese Transactions in* 1791,[2] Volta was Professor of Physics at Pavia, having been appointed to that post in 1774. As has been mentioned in a former section, the announcement of these researches excited the immediate attention of electricians and anatomists in every part of Europe. Of course Italy was not exempted from the general impulse. In that country physiological observations have always been prosecuted with interest and success; and indeed it has never been deficient in persons of ability, whether in physical or in purely mathematical enquiries, since the very dawn of letters, at which time Italy made so distinguished a figure in literary progress. Volta, Aldini, Valli, and Spallanzani were all, at the time of which I now speak, actively engaged in the pursuit of science; and Galvani's opinion that the commotion of the frog by the connection of the muscle and nerve through a "conducting arc" of metal was due solely to animal electricity, was generally adopted, and by none more cordially than by Volta in a letter and memoirs published in *Brugnatelli's Journal* early in 1792. These were speedily followed by two letters to Cavallo, dated October of the same year, and communicated to the Royal Society of London, in acknowledgement, as the author states, of the honour recently done him of electing him an Honorary Fellow. The title of this communication deserves notice,—"Account of some Discoveries made by Mr Galvani of Bologna, with Experiments and Observations on them;"[3] and also the first sentence (the letters are in French),—"Le sujet des découvertes, et des recherches, dont je vais vous entretenir, Monsieur, est *l'electricité animale.*" In the course of the paper, however, he distinctly states that whilst he agrees with Galvani in considering that the convulsions of the frog, obtained with homogeneous conductors, are due to a proper animal electricity (§§ 12, 16), the more powerful effects occasioned by the contact of unlike metals are caused by "common electricity" developed at the junction, and having the nature, not of a discharge, but of a continued stream. He repeats and modifies Galvani's experiments on animals, cold and warm-blooded, and makes interesting observations on the excitement of the nerves of taste and sight by the contact of unlike metals. The conclusion of his paper is in opposition to its earlier portion. He expresses a grave doubt whether there be any vital electricity in the matter.

His letters to Cavallo.

(748.) Volta receives the Copley Medal.

The induction of Volta was imperfect in this, that he did not prove that the effects which he attributed with great probability to the contact of metals produced any other recognised electric effect than the physiological ones. Galvani had gone very nearly as far. He had even hesitated between the terms animal electricity and electricity of metals; he had considered the frog as a very sensitive electrometer, exactly as Volta did; and the manner of so using and applying it is ascribed by the latter in this memoir to Galvani, who having thus invented the instrument which for years served alone to indicate the presence of the new species of electricity—and having also described accurately the influence of the heterogeneous metals in aiding the results—left to Volta only the credit of the assertion that in *some* instances the effect was due to the metals themselves, in others to the natural electricity of the animal frame. Under these circumstances, I think that the award of the Copley Medal by the Royal Society to Volta, rather than to Galvani, was a questionable decision: the great value of Volta's paper, at the time, was undoubtedly that it directed the attention of English experimenters to Galvani's discoveries, then quite recent and probably imperfectly known.[4]

(749.) Robison's anticipation of Volta's pile.

Many publications followed. I shall only notice that by Dr Fowler of Edinburgh (afterwards of Salisbury), which is remarkable as containing a letter by Professor John Robison (335), who first thought of increasing the effect of heterogeneous contact by using "a number of pieces of zinc made of the size of a shilling, and making them up into a rouleau with as many shillings." We have here unquestionably the first idea of the pile, which moreover was actually constructed. This was in May 1793. It was only applied, however, to excite the nerves of the senses.

(750.)

In various scattered memoirs, from 1793 to 1796,

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[1] His arguments as to the primary law of electric attractions and repulsions, are wholly inexact. His electrometer was unfitted for such enquiries.

[2] Vol. vii. His paper was reprinted separately at Modena in 1792.

[3] *Philosophical Transactions*, 1793.

[4] See the grounds of the award stated by Sir Joseph Banks. Weld, *Hist. R. Society*, ii., 202.

Volta's theory of electro-motion.

Invention of the pile.

Repulsion due to contact of metals.

we find Volta gradually insisting more on the purely mechanical nature of the electrical excitement. The last-named year produced an important letter to Gren of Halle,[1] which contains the real germ of the invention of the pile, though it has been little taken notice of. We there find conducting bodies divided into two classes, primary and secondary; the first including metals, metallic ores, and charcoal; the second liquids, solutions, animal tissues, &c. The first class he also called *motors*. Using the prepared frog always as an indicator, he tried the effect of combining three or more elements of the two kinds. He found that a double combination of three elements, when arranged so that their order was reversed, neutralized each other, or produced no spasm; on the contrary, when the two combinations conspired in direction, the convulsions were increased (§ § xii., xv., xix.). This appears to define the date of Volta's discovery of the principle of the pile —that, namely, of superadding minute effects—to be August 1796. The form of the arrangement resembled that afterwards adopted in the *Couronne des Tasses*. The second letter to Gren, dated the same month of August 1796, contains the important discovery (the most important abstractly of any due to Volta), that the electricity set in motion by the contact of unlike metals may, by means of the condenser (due also to him), be made evident by the usual effect of repulsion on the common electrometer:—thus when zinc and silver are used, the former is positive, the latter negative, and so of other metals. Volta used for this experiment Nicholson's ingenious modification of his own condenser, called a Revolving Doubler. It must be owned that the experiment, in its simplest form, is difficult of repetition, and that Nicholson's instrument sometimes gives delusive results. But Volta's great address in practical electricity, and his fairness in stating his results, leave no doubt of the reality of his discovery, which evidently for the first time eliminated the physiological element of Galvani's experiments, leaving the recognised mechanical effects of electricity due to the contact of unlike metals; and, therefore, deserved the highest honour which could be bestowed. Pfaff had already constructed a table of the electro-motive power of metals by their actions on the frog, in which zinc stood at one end, carbon at the other. But one of the most curious parts of the paper by Volta is the evidence of a strong suspicion which had crossed his mind, and been for a time entertained, that in his experiments with combinations of three elements—two metallic, and one humid—the electricity was developed separately at the contacts of the latter with the two former, and that the resulting current was merely the difference of the two in favour of the stronger. Truly in this whole history we may see how often first suggestions have a peculiar and intuitive worth, which reflection and controversy often only obscure! This is, of course, the case rather in the research of causes than of the means of rendering discovery practical.

(751). Fabbroni suggests the chemical origin of galvanism.

Whilst Volta was thus maintaining the opinion that the electricity excited by the contact of metals was entirely mechanical, and due to contact merely; —and whilst Galvani, his relative Aldini, and others, maintained strenuously the vital theory, in which they were substantially confirmed by no less authorities than Wells and Baron von Humboldt—a third school appeared, at first little popular, represented by Fabbroni, a Tuscan chemist and natural philosopher of no small merit. His papers published, I believe, in 1799, though written several years previously, and some as far back as 1792, of which a full abstract is given in Nicolson's *Journal*,[2] show great acuteness. He attributed the effects of the contact of metals to a chemical action developed at the place of contact. He referred to Sulzer's experiment of the taste of heterogeneous metals applied to the tongue—and to many instances of the rapid oxidation of heterogeneous metals in contact, when exposed to heat and moisture. Amongst others, by a remarkable anticipation of one of the most curious applications of the electro-chemical theory, he notices the oxidation of the copper sheathing of ships. Without "excluding all electrical influence from the prodigious effects of galvanism," he infers that there are chemical forces "exerted with the swiftness of lightning," to which the physiological effects, and perhaps some others ascribed to electricity, are probably due. Thus, he says, "the experiment of Sulzer is nothing more than a combustion or chemical operation, as is proved not only by its result but by its duration; for electricity acts always instantaneously, whereas the effect of chemical affinities continues so long as the re-agents are not saturated." The weak point of Volta's theory of electro-motion is here cleverly hit. That effects indefinitely prolonged, capable of producing mechanical, chemical, and vital changes, without any mutual action between the touching bodies, save mere pressure, appears indeed a paradox startling even to a first inventor, but which, when maintained by successive generations of able men, may rank as a delusion more memorable than the phlogistic theory of the older chemists. Fabbroni did not himself pursue his ingenious speculations, but his papers, though now almost forgotten, acted powerfully on the minds of his contemporaries, as we shall see in the next section. He died at the age of 70, in 1822, having spent most of his life in patriotic and useful labours in his native country.[3]

(752.) Volta's description of his pile, and its effects.

We have seen that already in 1796 Volta had arrived at a knowledge of the principle that the electric effect of the metals might be increased by combining two sets of triple elements similarly disposed, which, unknown to him, Robison had already done (749).

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[1] Volta, *Opere*, vol. ii., part 2.

[2] In quarto, vol. iv. (1800).

[3] See an account of him in the third volume of Cuvier's *Eloges*.

But three years seem to have elapsed before he was led to the invention of the pile, although it is in truth nothing more than the same arrangement frequently repeated. In March 1800 he wrote from Como a letter to Sir Joseph Banks, which was printed in the *Philosophical Transactions* for the same year, and in which he describes the Pile and the *Couronne des Tasses*. The former consisted of 20 or more copper or silver coins interlaid with as many disks of tin or zinc, and others of paper or leather, soaked in water or brine. The same order of sequence of the three elements was carefully preserved throughout; and the whole formed a vertical pile or *rouleau*. Several such piles could be used together. The effects were—1. The ready excitement of the common electrometer by the aid of the condenser; 2. The production of smart shocks through the hands and arms, similar to those produced by the torpedo; 3. The production of vivid sensations of taste, of sound in the ears, and of flashes of light. There was nothing new in these effects (it may be seen) except that their intensity was much exalted, and the verification of the metallic theory was thereby rendered more easy. Volta attributes the action to the effect of "simple contact" of the metals, allowing to the fluid element no other share than that of conducting sufficiently, but not too rapidly, the impulse thus excited. Having an eye probably to Fabbroni's opinions, he insists on the superior effects obtained with saline and alcaline fluids, and with hot in preference to cold fluids, being explicable solely by their increased conducting power. He justly describes the effects of the pile as similar to those of an immense electric battery with a very feeble charge; only the action is continuous, instead of intermittent.

(753.) But the invention had scarcely become known in London when the importance of the pile, as an instrument of discovery, was keenly appreciated in consequence of one capital discovery.

(754.) Nicholson and Carlisle obtain chemical effects from the pile.

Nicholson, a good electrician and chemist, and Carlisle (afterwards Sir Anthony), a medical man, were the first in England to construct one of Volta's piles. It consisted first of 17, afterwards of 36, half-crowns, with as many disks of zinc and of pasteboard, soaked in salt water. Experimenting upon the electrical effects of the pile, they used a drop of water "to make sure the contacts" upon the upper plate. Carlisle first observed a disengagement of gas round the wire which the water moistened. Nicholson suspected it to be hydrogen, and proposed to break the circuit by enclosing water in a tube between the two wires. This was accordingly done on the 2d May 1800, within a month of the arrival in England of the first four pages of Volta's letter to Sir J. Banks, which preceded the remainder by a considerable space of time. The brass wire in the water tube, which was connected with the positive end of the pile, became tarnished and black, whilst minute bubbles of gas were evolved from the other, to the amount of $\frac{1}{15}$th of a cubic inch in $2\frac{1}{2}$ hours. Being mixed with an equal quantity of common air, and a lighted waxed thread being applied, it exploded. It was, therefore, concluded to be hydrogen derived from the decomposition of the water, whose oxygen had combined with the brass of the positive wire.[1] Nicholson, it appears, was well acquainted with Fabbroni's writings on the relation of galvanism to chemical action; and in the very paper where he describes Volta's pile and his own discovery, he expresses his astonishment that Volta should have taken no notice of Fabbroni's results, or of the rapid oxidation of zinc in contact with other metals which appears in the pile, and which had been noticed by Fabbroni in every case where two metals differing in oxidability are placed in water, and in contact with each other. The experiment was repeated at Vienna, and then by Volta himself, who called attention to an experiment by three Dutch chemists, Paets, Van Troostwyk, and Dieman, who had decomposed water by common electricity in 1789.

(755.) Volta receives distinctions from Napoleon, and from the Institute of France—

Volta, himself, however, did not enter with zeal upon this new career; he even left to others the task of improving the form and increasing the energy of his battery, which was first done by the useful arrangement of Cruickshank. He was now approaching his 60th year, and seems to have been not indisposed to pass an old age of ease, and to receive in tranquillity the marks of distinction which were showered upon him. In 1801 Napoleon called him to Paris, attended the meeting of the Institute where Volta explained his theory of the pile, caused to be voted to him on the spot a gold medal, and sent him home with a valuable present in money. He was then made a Senator, finally a Count: he was also made an Associate of the Institute in 1802. No scientific discovery ever excited the enthusiasm of Napoleon to the same degree as that of the Pile. He even extemporized a theory of life from its phenomena, comparing the vertebral column in man to the pile, the bladder being the positive and the liver the negative pole. An eminent medical chemist, Dr Prout, has seriously maintained a somewhat similar hypothesis. The favours lavished on Volta excited, perhaps, some jealousy amongst the French philosophers; for it is remarkable how little was added in France to the progress of the revived science of electricity. The French ruler, however, had himself in some measure to blame for this; for the rigid exclusion of foreign, and especially of English publications, for a number of years, was felt to be highly injurious, and was in vain remonstrated against by Berthollet and others.

(756.) His death.

Volta survived his great invention above a quarter of a century. He died 5th March 1827, aged 82.

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[1] Nicholson's *Journal* (series in quarto), iv., 182.

(757.) His scientific character. His scientific character is easily summed up. He was patient, intelligent, and devoted to science from youth to age. He had, in an eminent degree, that patience and tenacity of purpose and of interest which Newton described as the chief attributes of his own genius. He had the candour which is more especially to be desired in the experimentalist; and he wrote without pretension, and generally clearly, though not without that diffuseness which is often associated with the use of the Italian language even in matters of science. On the other hand, his intellect may be rather described as opening itself to conviction, than as forcing its way by a native power of penetration to great results. His taste and his talent lay far more in experimental than in abstract reasoning. His explanations of the effects which he observed were often involved and obscure; yet he had a very happy talent of combination, which led him to effect what others only talked about. His instrumental inventions, including the pile, were his happiest efforts. His theories, on the other hand, were surrounded, even in his own mind, with a certain obscurity. Even the contact theory, with its manifold paradoxes, was perhaps only vigorously carried out by him under the excitement of an active controversy. The invention of the pile may, in very many respects, be placed on a par with that of the steam-engine. The results of the former were indeed more interesting, immediately, to pure science; the latter to the arts of life and the needs of civilization. Yet, after half a century, this distinction can hardly be drawn with severity. The rapid pace of steam is insufficient for our demands. The electric wire conveys to its destination, ere the locomotive has time to start on its journey, tidings of joy and sorrow—life and death—of victories won, and kingdoms lost.

§ 3. Sir Humphry Davy. *Progress of Voltaic Electricity—Electro-Chemistry;* Berzelius.—*Davy's Invention of the Safety-Lamp.*—Wollaston; *his Electrical and other Observations. Contrast of his Character with that of Davy.*

(758.) History of the pile of Volta continued. The pile of Volta was, in one sense, rather a means of discovery than a discovery itself. Volta had neither a just theory of the source of power which he invented, nor was he successful in applying it to any important research. The discovery of its chemical efficiency by Nicholson and Carlisle, stimulated, as we have seen, for a short time his interest and curiosity; but he never seriously attached himself to this line of discovery. His subsequent papers are chiefly controversial, in support of the Contact theory. The generation, as well as the expenditure of chemical forces by the pile, consequently remained, as far as he was concerned, in complete obscurity.

(759.) Cruickshanks, Wollaston, Davy. The invention of the pile having been communicated to the world through the Royal Society, naturally gave an impulse to English electricians and chemists. The first discoverers of its chemical energy did not however themselves prosecute their experiments to a great extent, but Cruickshanks decomposed salts and *revived* the metals by the voltaic current, whilst he improved the form of the apparatus in an important manner. Colonel Haldane ascertained the significant fact that the action of the pile cannot be continued in an atmosphere deprived of its oxygen. Hisinger and Berzelius, carrying out Cruickshanks' experiments, showed that, *generally* in the decomposition of compounds, the alcaline and metallic elements appear to be attracted towards the negative wire of the battery, and the acids to the positive one. In the mean time, Davy and Wollaston appeared on the arena, and the former especially filled so important a part in the history of science for the next twenty years, that we can hardly give his name too great a prominence in a review of the characteristics of the period. The constitution of Davy's mind was also more than usually interesting, and his career of discovery, short, brilliant, and decisive, is at once one of the most instructive and remarkable of those which we have to consider. The contrast between him and his contemporary, Wollaston, was one of those curious antitheses of really great minds which occasionally occur in such close connection, and with such prominent relief, as to compel rather than invite a comparison between them. It is an instructive lesson to observe, how natures, the most unlike, cultivated in a school the most opposite, may yet, when both directed by a common impulse to similar objects, promote the development of truth, and the cause of scientific discovery.

(760.) Sir Humphry Davy—his early history and remarkable genius. Sir Humphry Davy was born at Penzance on the 17th December 1778. His was an ardent boyhood. Educated in a manner somewhat irregular, and with only the ordinary advantages of a remote country town, his talents appeared in the earnestness with which he cultivated at once the most various branches of knowledge and speculation. He was fond of metaphysics; he was fond of experiment; he was an ardent student of nature; and he possessed at an early age poetic powers, which, had they been cultivated, would, in the opinion of competent judges, have made him as eminent in literature as he became in science. All these tastes endured throughout life. Business could not stifle them,—even the approach of death was unable to extinguish them. The reveries of his boyhood on the sea-worn cliffs of Mount's Bay, may yet be traced in many of the pages dictated during the last year of his life amidst the ruins of the Coliseum. But the physical sciences—those more emphatically called at that time chemical—speedily attracted and absorbed his most earnest attention. The philosophy of the imponderables—of Light, Heat, and Electricity—was the subject of his earliest, and also that of his happiest essays. He was a very able chemist in the strictest sense of the word, although his ardour and his rapidity of generalizing might seem to unfit him, in some measure, for a pursuit which requires such intense watchfulness with regard to minutiæ, such patient weighings of fractions of a grain, such frequent though easy calculations. To Cavendish and Dalton, his great contemporaries—to whom we may now add Wollaston—these things were a pleasure in themselves; to Davy they must ever have been irksome indispensables to the discovery of truth. But, in fact, Davy's discoveries were almost independent of such quantitative details: Numerical relations, and harmony of proportion, did not affect his mind with pleasure, which possibly was one reason of his deficient appreciation of works of art, the more remarkable from his poetic temperament. Dalton's doctrine of atomic combinations was (as we have seen) slowly and doubtfully received by him whilst Wollaston perceived its truth instantaneously. A keener relish for such relations might most naturally have led Davy to an anticipation of Mr Faraday's notable discovery of the definite character of electrical decomposition, and the coincidence of the Electro-chemical proportions for different bodies with their atomic weights.

(761.) His first papers, and experiments on nitrous oxide.

The early papers of Davy refer chiefly to Heat, Light, and Electricity. He was, in fact, a physicist more than a chemist. Whilst yet a surgeon's apprentice at Penzance, he satisfied himself of the immateriality of heat, which he illustrated by some ingenious experiments, in which, concurring unawares with the conclusions of his future patron Rumford, he laid one foundation of his promotion. Removed to a sphere of really scientific activity at Clifton, under Dr Beddoes,[1] he executed those striking researches in pneumatic chemistry and the physiological effects of breathing various gases which gave him his first reputation; researches so arduous and full of risk as to require a chemist in the vigour of life, and urged by an unextinguishable thirst for discovery, to undertake them. Even his brilliant discovery of the effects of inhaling nitrous oxide brought no competitor into the field; and the use of anæsthetics, which might naturally have followed—the greatest discovery (if we except, perhaps, that of vaccination) for the relief of suffering humanity made in any age—was delayed for another generation. But so it was in all his triumphs. He never seemed to drain the cup of discovery. He quaffed only its freshest part. He felt the impulse of an unlimited command of resources. He carried on rapidly, and seemingly without order, several investigations at once. As in conversation he is described as seeming to know what one was going to say before uttering it,—he had the art of divining things complex and obscure. Seizing on results, he left to others the not-inconsiderable merit, as well as labour, of pursuing the details. Keenly alive as he was to the value of fame, and the applause which his talents soon obtained for him, he left enough of both for his friends; his contemporaries, as well as his successors, were enabled to weave a chaplet from the laurels which he had not stooped to gather.

(762.) Removed to the Royal Institution—experiments on voltaic electricity.

These remarks apply quite as strongly to his discoveries in the laws and facts of electro-chemical decomposition—those on which his fame most securely rests. Promoted in 1801 to a situation in the Laboratory of the Royal Institution in London, he attached himself to the study of galvanism in the interval of the other and more purely chemical pursuits which the duties of his situation required. He had already, at Clifton, made experiments with the pile of Volta, and taken part in the discussion of its theory and effects, then (as we have seen) so actively carried on in Britain. In his papers of that period we find not only excellent experiments, but happy and just reasoning. The chemical theory of the pile—namely, that the electrical effects observed by Galvani and Volta are due solely or chiefly to the chemical action of the fluid element on the metals—was more strongly embraced by him then than afterwards. In November 1800 he concluded that "the pile of Volta acts only when the conducting substance between the plates is capable of oxidating the zinc; and that in proportion as a greater quantity of oxygen enters into combination with the zinc in a given time, so in proportion is the power of the pile to decompose water and to give the shock greater." He concludes that "the chemical changes connected with" oxidation "are *somehow* the cause of the electrical effect it produces."[2] His views on this subject underwent some modification afterwards. In his *Elements of Chemical Philosophy*, published twelve years later, we find the following statement of his opinions on the subject:—"Electrical effects are exhibited by the same bodies acting as masses, which produce chemical phenomena when acting by their particles; it is, therefore, not improbable that the primary cause of both may be the same." A little further on he adds:—"They," speaking of electrical and chemical energies, "are conceived to be *distinct* phenomena, but produced by the *same power* acting in the one case on masses, in the other on particles."[3]

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[1] Davy hit off his principal's character in a single sentence,—"Beddoes had talents which would have exalted him to the pinnacle of philosophical eminence, if they had been applied with discretion."

[2] *Works*, ii., 162.

[3] *Works*, iv., 119. In his Bakerian lecture (1806), he had said, "In the present state of our knowledge, it would be useless to attempt to speculate on the remote cause of the electrical energy, or the reason why different bodies, after being brought into contact, should be found differently electrified; its relation to chemical affinity is, however, sufficiently evident. May it not be identical with it, and an essential property of matter?"—*Works*, vol. v., p. 39.

(763.) Electro chemical theory—Berzelius, Hisinger—Davy's first Bakerian lecture.

Electro-chemical Theory—Decomposition of the Alcalies.—In 1804 Berzelius had published, in conjunction with Hisinger, a paper on Electro-chemical Decompositions, in which he insisted on the general fact, that alcalies, earths, and combustible bodies seem to be attracted to the negative pole, and oxygen and acids to the positive. He also showed that the subdivision of bodies thus obtained was only a relative not an absolute one; for the same body may act as a base to a second, and as an acid to a third. But we must observe that results almost similar were contained in the early papers of Davy, and that Berzelius did not carry out his own principle so far as to lead to any striking discovery between 1803 (when his experiments were made) and 1806 (the date of Davy's first Bakerian lecture), during which time the science of Galvanism or Voltaism made little real progress. The numerous experimenters engaged with it were baffled by the anomalous chemical results obtained, and by the appearance of decompositions under circumstances wholly unexpected, such as appeared to threaten the existence of some of the best established chemical truths. The chemical theory of the pile, at first so plausible, presented new difficulties, and Berzelius having for a while defended it, returned to the simple contact theory of Volta. It was then that Davy seriously addressed himself to the subject, resolved to trace to their source every chemical anomaly; and this he effected in a masterly manner in his Bakerian lecture read before the Royal Society in 1806. In it he traces the unaccountable results of his predecessors to impurities in the materials used by them, or to those of the vessels in which the decompositions were made; and he brings into a far distincter light than his predecessors had done, the power of the galvanic circuit to suspend or reverse the action of even powerful chemical affinity; "different bodies naturally possessed of chemical affinities appearing incapable of combining or of remaining in combination when placed in a state of electricity different from their natural order." We here see the fundamental doctrine of the electro-chemical theory, that all bodies possess a place in the great scale of natural electrical relations to one another; that chemical reactions are intimately connected with this electric state, and are suspended or reversed by its alteration.

(764.) Davy's sagacious inductions respecting polar forces.

In the interpretation of those striking experiments, in which he caused acids to pass to the positive pole of the battery through the midst of alcaline solutions, and the converse, we find so close an approach to the theory of polar decomposition as enforced by the discoveries and reasoning of Mr Faraday, that it seems impossible to deny to Davy the merit of having first perceived these curious relations. "It is very natural," he says, "to suppose that the repellant and attractive energies are communicated *from one particle to another particle* of the same kind so as to establish a conducting chain in the fluid, and that the locomotion takes place in consequence;" and presently adds, "there may possibly be a succession of decompositions and recompositions throughout the fluid" (p. 29).[1] He likewise shows (p. 21) that the decomposing power does not reside in the wire or *pole*, but may be extended indefinitively through a fluid medium capable of conducting electricity. Mr Faraday's experiments, which led him to discard the term *pole*, lead to the same conclusion, and are of the same character. A few pages further on in this same Bakerian lecture, Davy observes (p. 42), that "allowing that combination depends on a balance of the natural electrical energies of bodies, it is easy to conceive that a *measure* may be found of the artificial energies as to intensity and quantity capable of destroying this equilibrium; and such a measure would enable us to make a scale of electrical powers corresponding to degrees of affinity." Here we see the acute presentiment of the beautiful discovery of the definiteness of electrical decompositions; as in the concluding portion of the same remarkable paper we find a clear anticipation of natural electrical currents to be discovered in mineral, and especially metalliferous deposits, since established by Mr R. W. Fox, and of the agency of feeble electric energies, long continued, in effecting geological changes, and in producing insoluble combinations of earths and metals, so ingeniously confirmed by the beautiful and direct experiments of Becquerel.

(765.) Second Bakerian lecture—decomposition of the alcalies.

The sequel to this remarkable paper, read to the Royal Society in November 1807, contained the splendid application of the principle and methods which it described, to the decomposition of the alcalies and to the discovery of their singular bases,—substances possessing the lustre and malleability of metals, yet so light as to float upon water, and having the extraordinary property of becoming inflamed in contact with ice. Potassium was discovered in the Laboratory of the Royal Institution on the 6th October 1807, and sodium a few days later. The battery used contained 250 pairs of plates of 6 and 4 inches square. Such success was fitted to charm a disposition like that of Davy, and more than reward him for all his toils. To have discovered two new bodies, and opened an entirely new field of wide chemical research, would itself have been enough. But the extraordinary properties of the new bases were such as seemed to correspond to the lively imagination of the Chemist who produced them, and to transport him to an Aladdin's palace more brilliant than even his fertile imagination had ever conceived. Yet it is pleasing to remember that these popular discoveries followed, at the interval of a year, the patient and able researches which led him to them, and which had already been rewarded, at a period of the bitter-

Receives a prize from the Institute of France.

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[1] Of the Bakerian Lecture, in his collected Works.

est international hostilities, by the scientific prize of 3000 francs, founded by the Emperor Napoleon.[1]

(766.) Distinguished testimonies to his scientific character.

The genius displayed in these, Davy's most celebrated researches, is evident on a careful perusal of his papers; but still more from a consideration of the state of science of the time, and of the willing tribute to his merits paid by the ablest of his contemporaries. Few persons of the present day will venture to controvert the assertion of his acute contemporary, Dr Thomas Young (than whom no man was ever a less indiscriminate eulogist), that Davy's researches were "more splendidly successful than any which have ever before illustrated the physical sciences, in any of their departments;" and that the contents of the *Bakerian Lectures*, in particular, "are as much superior to those of Newton's *Optics*, as the *Principia* are superior to these or any other human work."[2] A not less impartial tribute to his superlative genius has been yielded by M. Dumas, who, if I mistake not, has described Davy as being the ablest and most successful chemist who ever lived. A similar homage is paid to him by the sagacious Cuvier.

(767.) Chemical researches on chlorine and iodine.

It is not within our scope to consider minutely Davy's purely chemical discoveries and experiments, though they were numerous and important, independently of those made with the aid of electricity. His proofs of the elementary nature of chlorine and iodine were amongst the most considerable in their results. But as a mere analyst, Davy had neither the leisure nor the taste for continuous plodding labour, and he therefore naturally made mistakes in chemical details. His *Elements of Chemical Philosophy* remained, in consequence, a fragment of an extensive work. His contemporary, Berzelius, following his steps in electro-chemical discovery, attained far greater address, and became an author of high and merited reputation, whilst his school surpassed all others in Europe in producing accomplished analysts.[3]

(768.) Davy's extensive popularity, and its results.

The years immediately following the publication of his *Bakerian Lectures* were passed by Davy in the unenvied possession of the highest fame, and in the tranquil furtherance of his first and greatest discoveries. His lectures at the Royal Institution continued to be one of the most fashionable resorts in London, and he was freely admitted in return into the most aristocratic society; he had but to express a wish, and a voltaic battery of no less than 2000 pairs, containing 128,000 square inches of surface, was constructed for his use, by means of a liberal subscription. His health, when seriously compromised by the severity of his labours, was a matter of public concern, and its variations were announced by frequent bulletins. The copyright of his lectures on agriculture was sold for a price unexampled perhaps before or since for such a work. In 1812 he was knighted by the Prince Regent, and soon after he married a lady of fortune and accomplishments. His duties at the Royal Institution became thenceforth honorary. He had in a space of ten years attained the pinnacle of scientific reputation, and he was for the time truly happy:—unenvious of others—deeply attached to his relatives—generous of his resources—unwearied in his philosophic labours. A certain change (it must with regret be owned) came over his state of mind, tarnished his serenity, and gradually though imperceptibly weakened his scientific zeal. It was to be ascribed solely, we believe, to the severe ordeal of exuberant but heartless popularity which he underwent in London. The flatteries of fashionable life acting on a young, ardent, and most susceptible mind, mingling first with the graver applause of his philosophic compeers, and at length, by their reiteration and seductions quite overpowering it, by degrees attached Davy to the fashionable world, and loosened his ties to that laboratory which had once been to him the sole and fit scene of his triumphs. Had he been blest with a family, his course would probably have been evener and happier. Let us not severely criticise, where we still find so much to admire and to imitate. But we record the fact, for the consolation of those who, beginning the pursuit of science, as Davy did, in a humble sphere, and with pure ardour, may fancy that they are worthy of pity, if they do not attain with him the honours of wealth and title, and the homage, grateful to talent, of rank, wit, and beauty.

(769.) Third period of his life.

A research, second perhaps only to his electro-chemical discoveries, remains to be noticed, as the chief fruit of the *third* period of his life, on which we now enter; the *first* being his early career before settling in London; the *second*, that passed in the Royal Institution.

(770.) Researches on flame—the safety-lamp.

Researches on Flame—The Safety-Lamp.—The subject was, the laws of combustion, and the happy invention of the safety-lamp. Though intimately connected with the doctrine of simple heat, it may, most properly, from its chemical character, and from its connection with Davy's history, be considered briefly here. The lamentable loss of life occurring in coal mines from explosions of fire-damp or inflammable air disengaged from the workings, had for many years attracted the attention and sympathy of the public, and had likewise been carefully considered by scientific men. The explosive gas was known to be the light carburetted hydrogen. Two plans alone seemed to present themselves for diminishing the danger:—the one to remove, or chemically to decompose the fire-damp altogether; the other, to provide a miner's lamp which, by its construction, should be incapable of causing explosion. The former of these modes of protection, it was soon seen, could only be palliative; the only efficient form which it took, was that of a more effectual ventilation; but the terrific rapidity with which a mine may be suddenly invaded by fire-damp, from channels opened by a single blow of the pickaxe, must prevent it from ever acting as a *cure.* The latter plan had as yet yielded nothing more effectual than the *steel mill* long used by miners, which produced an uncertain and intermitting light, by the rotation of a steel wheel against a flint, the scintillations of which were incapable of inflaming the fire-damp. The insufficiency of the light prevented it from being used, except in circumstances of known danger. The celebrated Baron Humboldt, Dr Clanny, and several others, had invented safety-lamps on different principles; but they were all clumsy and more or less ineffectual.[1]

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[1] Such was the national feeling at this time in England, that worthy people were found who considered Davy as almost a traitor, when he accepted the French prize. See Southey's *Life*.

[2] *Quarterly Review*, No. 15.

Berzelius.

[3] Jöns Jacob Berzelius, the greatest analytical chemist of his day, was born in East Gothland, in the same year with Davy, and died in 1848, when he had almost completed his 69th year. He contributed, in a signal manner, to the establishment of Dalton's principle of definite chemical equivalents; but he made no single discovery of commanding importance.

(771.) History of the invention of the safety lamp.

At last, in the summer of 1815, the Rev. Dr Gray (afterwards Bishop of Bristol), then chairman of a committee appointed by a benevolent association at Bishop Wearmouth for the prevention of colliery accidents, applied to Davy, who was then on a sporting tour in Scotland, requesting his advice and assistance. Sir Humphry answered the call with promptitude. On his southward journey, in the latter part of August, he visited the collieries, ascertained the circumstances of the danger which he had to meet, and was provided by Mr Buddle with specimens of the inflammable air for examination. Within a fortnight after his return to London, he had ascertained new and important qualities of the substance, and had already four schemes on hand for the prevention of accident. Before the end of October, he had arrived at the following principles of operation in connection with a safety-lamp. "First, A certain mixture of azote and carbonic acid prevents the explosion of the fire-damp, and this mixture is necessarily formed in the safe-lantern; secondly, The fire-damp *will not explode* in tubes or feeders of a certain small diameter. The ingress to, and egress of air from my lantern," he adds, "is through such tubes or feeders; and, therefore, when an explosion is *artificially* made in the safe-lantern, it does not communicate to the external air." The effect of narrow tubes in intercepting the passage of flame, is due to the cooling effect of their metallic sides upon the combustible gases of which flame is composed;[2] and one of his first and most important observations was the fortunate peculiarity that fire-damp, even when mixed with the amount of air most favourable to combustion (1 part of gas to 7 or 8 of air), requires an unusually high temperature to induce combination. Olefiant gas, carbonic oxide, and sulphuretted hydrogen, are all inflamed by iron at a red heat, or ignited charcoal, but carburetted hydrogen does not take fire under a *perfect white heat.* The earliest safety-lamp consisted of a lantern with horn or glass sides, in which a current of air to supply the flame was admitted below by numerous tubes of small diameter, or by narrow interstices between concentric tubes of some length; or, finally, by rows of parallel partitions of metal, forming rectangular canals extremely narrow in proportion to their length. A similar system of escape apertures was applied at the top of the lantern.

(772.) The safety lamp perfected.

With characteristic ingenuity, Davy did not stop here. He continued to reduce at once the apertures and length of his metallic guards, until it occurred to him that *wire gauze* might, with equal effect, and far more convenience, act upon the temperature of flame, so as to reduce it below the point of ignition, and thus effectually stop its communication. The experiment was successful, and by the 9th November 1815, or within about ten weeks after his first experiments, an account of the safety-lamp defended by wire gauze was presented to the Royal Society. About two months later he produced a lamp entirely enveloped in metallic tissue.

(773.) Considered as a model for similar investigations.

There are none of Davy's researches which will stand a closer scrutiny than those which terminated thus successfully. No fortuitous observation led him to conceive a happy idea and to apply it to practice. A great boon to humanity and the arts was required at his hands; and without a moment's delay, he proceeded to seek for it under the guidance of a strictly experimental and inductive philosophy. Without, perhaps, a single false turn, and scarcely a superfluous experiment, he proceeded straight to his goal, guided by the promptings of a happy genius aided by no common industry. The chemical, the mechanical, and the purely physical parts of the problem were all in turn dealt with, and with equal sagacity. It may safely be affirmed that he who was destitute of any one of these qualifications must have failed in attaining the object so ardently desired, unless by the aid of some rare good fortune. We have it on Davy's own authority, that none of his discoveries gave him so much pleasure as this one. His whole character possessed in it much of a sympathizing and generous humanity; his ideas of the dignity of science were from the first (as his researches in Dr Beddoes' laboratory showed) intimately connected with the aim of advancing the welfare, and of diminishing the misfortunes of mankind: the rapidity and singular success of his investigation in the case of the safety-lamp, kept his ardent soul all alive, and afforded him the triumph of a *Eureka* at its completion. To these sources of inward gratification was added the unstinted meed of praise bestowed on him by his contemporaries. Playfair,

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[1] I have spoken in Art. 393 of the independent and ingenious efforts of George Stephenson towards the invention of a safety-lamp contemporaneously with those of Davy.

[2] This fact had been ascertained some years previously, by Mr Tennant and Dr Wollaston, but it remained unpublished, and was not applied by them to the prevention of colliery explosions.

"the true and amiable philosopher," as Davy long before described him, thus proclaimed his victory in the *Edinburgh Review*:—After describing the course of a discovery "which is in no degree the effect of accident," he adds, "this is exactly such a case as we should choose to place before Bacon were he to revisit the earth, in order to give him, in a small compass, an idea of the advancement which philosophy has made since the time when he had pointed out to her the route which she ought to pursue. The result is as wonderful as it is important. An invisible and impalpable barrier made effectual against a force the most violent and irresistible in its operations; and a power that in its tremendous effects seemed to emulate the lightning and the earthquake, confined within a narrow space, and shut up in a net of the most slender texture—are facts which must excite a degree of wonder and astonishment, from which neither ignorance nor wisdom can defend the beholder."

(774.) Rewards.

For this truly patriotic labour, the only *national* testimony which Davy received was the inadequate one of a baronetcy, which was conferred on him by the Prince Regent in 1818; but his real triumph and great reward were in the enthusiastic appreciation of his entire success by those on whom he had disinterestedly conferred so great a benefit. A testimonial, in the form of a service of plate, of great value, was presented to him by the coal-owners of the north of England.

(775.) Davy modifies Lavoisier's theory of combustion.

Davy's researches on flame were intimately connected with his electrical and chemical discoveries. He remodelled Lavoisier's theory of combustion, and put an end to the distinction between combustibles and supporters of combustion. Chemical combination, effected with great energy, and accompanied by a high temperature, is essential to combustion, and either element of the combination is equally entitled to the denomination of combustible. Guided by the electro-chemical theory, Davy appears to have thought that the heat of flame has an electrical origin.

(776.) Davy's protectors for ships.

But I must hasten to close this section. Among the labours of his latter years, there was none which interested Davy more, or which reasonably promised more useful results, than his plan for protecting the copper sheathing of ships from the corrosive action of sea water, by affixing plates of zinc or iron, which should render the copper slightly electro-negative, and thus indispose it for combining with acid principles. It is a somewhat singular fact that Fabbroni, about 30 years before, had instanced the corrosion of copper sheathing near the contact of heterogeneous metals, as an instance of the chemical origin of galvanism.[1] Davy's experiments were conducted with his usual skill and success, and the remedy only failed of general adoption on account, it may be said, of being *too* effectual, other and opposite injurious effects having been found to arise.

(777.) Davy as President of the Royal Society—his death.

Davy was elected President of the Royal Society in 1820, in the room of Sir Joseph Banks, who had held the office for 42 years. It was a distinguished compliment, for the election was all but unanimous. He continued to communicate papers for several years subsequently; but his energy, his temper, and, finally, his health began to give way—showing that the ardent labours of his youth and prime had injured his constitution. Attacked with paralysis in 1827, he spent his last years chiefly abroad, and died at Geneva (where he was buried), on the 29th May 1829.

(778.) Philosophical character.

The character of Davy was a rare and admirable combination. The ardour of his researches, and the deep devotion of his whole being to scientific investigation, have been already proved. They had the effect of completely annihilating every baser passion. He valued property only in so far as he could apply it usefully; and his disinterestedness with respect to the fortunes which several of his practical discoveries might have honourably earned, was one of the most striking parts of his character. His fancy was discursive to a degree rarely met with in men of science. He continued to write poetry nearly all his life, and the tone of it was that of grave speculation, always reverting to the destiny of man and the beneficence of the Creator. His lectures were composed with care; and their effect, even as pieces of oratory, was striking. Coleridge frequented them "to increase his stock of metaphors;"—yet they were always to the point, and never degenerated into rhetorical display. For a man of such extraordinary liveliness of fancy and impetuosity of action, his mistakes were astonishingly few. After his very first experience, his publications were made with great care and judgment. His estimates of his contemporaries appear generally to have been fair and liberal, though it would be incorrect to affirm that he was universally popular among them. The combination of isolated and intense occupation in his laboratory, with excitement in the mixed society of an admiring London public, was a trial which few, if any, could have escaped better than he did; and so far as we can judge of a man from his expressed opinion of his own successes, whether recorded in his works or in his intimate correspondence, Davy must be accounted to have acquitted himself gracefully and well. He always spoke of the Pile of Volta as the first source of his own success. "Nothing tends so much to the advancement of knowledge as the application of a new instrument," he says; and then adds, "The native intellectual powers of men in different times are not so much the causes of the different success of their labours, as the peculiar nature of the means and artificial resources in their possession;" a proposition which he applies to his own discoveries. But we may truly say with one of his biographers, that to him "the Voltaic apparatus was the *golden branch* by which he subdued the spirits that had opposed the advance of previous philosophers; but what would its possession have availed him had not his genius, like the ancient sybil, pointed out its use and application?"

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[1] There appears, however, to have been something erroneous in the details of Fabbroni's observations, or at least in the account of them given in *Nicholson's Journal*.

(779.) Numerous practical inventions.

The last, and not least, extraordinary characteristic of Davy to which I shall now advert, was the highly practical turn of a mind which seemed formed in a speculative mould. Four at least of his chief researches were of this kind—his experiments on breathing the gases; his lectures on agricultural chemistry; his invention of the safety-lamp; and his protectors for ships. No man, whose path so clearly lay in original discovery, ever left so many valuable legacies to art and to his country.

(780.) Davy's associates—Young and Wollaston.

The name of Davy gave to England a distinguished pre-eminence in science during the first 25 years of the century. But two others, less noticed at the time, were also among her worthiest sons. These were Young and Wollaston. They were all three nearly contemporaries; all lived on good terms with one another, and united in promoting natural knowledge in their several spheres. Young was Davy's early, though less successful colleague at the Royal Institution; and Wollaston was joint-secretary with him to the Royal Society. All three were originally educated for the medical profession, and they all abandoned it for the pursuit of science. Not the least singular coincidence was in the periods of their deaths, which all occurred within the space of six months.

(781.) William Hyde Wollaston—his contributions to Electricity,

Our notice of Young, the first optical philosopher of his age, belongs to another chapter. **Wollaston**, though an original observer in nearly every branch of exact science, considered himself as a chemist; and his observations on Electricity were amongst his first and best contributions to science. After the impulse given to discovery by the invention of the Pile, and the proof of the decomposition of water, Wollaston undertook to compare critically the effects of galvanic and frictional electricity—a task of some nicety, and of very great importance at a time when it could hardly be considered as certain that these agents were not specifically different. By methods peculiarly his own, he produced decomposition, accompanied with separation of the elements at the respective poles by means of common electricity. He at the same time gave his powerful support to the purely chemical theory of the Pile.

(782.) and the other sciences.

His most important inventions were rather instruments which, in the hands of others, were to produce important discoveries, than discoveries in themselves. One was the invention of the Reflecting Goniometer for measuring the angles of crystals, now so essential to mineralogy; another, the art of rendering platinum malleable, which has conferred inexpressible benefits on chemistry, and on the arts connected with it. The principle of the reflection of a ray of light for measuring angular spaces, though it existed already in the single instance of the sextant, has been, since it was applied to the goniometer, adapted to a multitude of most ingenious and valuable contrivances.

(783.) Wollaston was an excellent optician, and of some of his observations I have already spoken (476), (538).

(784.) His character contrasted with that of Davy.

The strong points of his character were precision and rare acuteness in observation, patience and caution in deduction, and habitual devotion of his time and energies to scientific pursuits. His foibles were an *excess* of caution, and a certain microscopic turn of mind which, though it sometimes rewarded him with valuable discoveries, consumed his time in occupations of mechanical ingenuity, and prevented him from grappling with almost any of the great theories of his day. An exception, yet one which illustrates his character, may be found in the fact that he had all but anticipated Dalton in his discovery of the multiple combinations of salts, whilst, with his characteristic sense of justice, he disclaimed any participation in the merit (624). While Davy was delighting crowded audiences with his eloquence, his discoveries, and their wonderful results, Wollaston was pursuing his solitary experiments on a scale so small that scarcely three persons could witness them at once. While Davy was firing his potassium with ice, and making mimic volcanos heave by the oxidation of his new metals, Wollaston was extracting, by minute analyses, from the refractory and unoxidable ores of platinum, substances previously undetected, which, neither by their quantity nor their characters, could ever interest any but a man of science. While Davy was charging his prodigious battery of 2000 pairs,—the largest which has ever been constructed (a homage to his genius, provided by his numerous admirers),—Wollaston was proving, after his fashion, how similar effects could be produced by the very same agency on a small scale; and with no greater apparatus than a shred of zinc, a few drops of acid, and an *old thimble*, he would gratify his friends by exhibiting the mimic glow of an almost microscopic wire of platinum. Davy seemed born to believe; Wollaston to doubt. Davy was a poet; Wollaston, a mathematician, or, at least, capable of becoming a great one. Davy announced his discoveries in fiery haste, and presented all their consequences and corollaries as a free gift to mankind; Wollaston (estimating more truly the rarity of the inventive faculty) hoarded every observation, turned it over and over, polished it, rendered it exact beyond the reach of criticism, and then deliberately laid it before the world. He had the coldness and the accuracy of Cavendish, but he wanted the spur of his genius, and the wide grasp of his apprehension. Among other legitimate results of discovery, Wollaston was not unwilling to claim for his own the material profits which such researches sometimes, though rarely, yield; whilst Davy, as we have seen, spurned every possible attribution of an interested motive. Davy never made a shilling in his life, save as an author or a lecturer (except as paid assistant to Dr Beddoes); Wollaston realized a fortune by his art of working platinum. Davy was admired by thousands both at home and abroad; Wollaston was little known except to a small circle who could appreciate the resources of a mind rarely opened in confidence to any one, and of which the world was only partially informed.

(785.) His death. Wollaston was born in 1766, and died in December 1828. The composure of his end rivalled that of Black and Cavendish. His disorder was one of the brain. When he had lost the power of speech, his attendants remarked aloud that he appeared unconscious. Making a sign for a pencil and paper, he wrote down a column of figures, added them up correctly, and expired.

§ 4. OERSTED. — AMPERE. — *Discovery of Electro-Magnetism — Electro-Dynamic Theory — Discovery of Thermo-Electricity;* SEEBECK. *The Galvanometer of* Schweigger *and* Nobili.

(786.) Oersted rendered famous by a single discovery. HANS CHRISTIAN OERSTED was born in Langeland, one of the Danish isles, on the 14th August 1777. Of him it might almost be said that "on awaking one morning he found himself famous." The single discovery of the mutual action of magnets and electric conductors gave him a celebrity which a life-long devotion to science has oftener than the contrary failed to secure.

(787.) Yet in this, and perhaps every similar case, it will be found that brilliant, and, as the world, or jealous rivals esteem it, fortunate success, was not the result of an isolated effort, but was connected with a long career of patient though comparatively obscure labour.

(788.) His early studies. At the age of 20, Oersted, whilst yet a student at the University of Copenhagen, became an author. His first publication was a prize essay on an æsthetical subject. Being intended for the medical profession, he soon after wrote some chemical papers, and, in 1801, his first "On Galvanic Electricity." But his turn of mind at this time, as well as later, was of a strongly metaphysical cast, and of course tinctured with the peculiarities of the German school as regards the study of physics, of which the title of his thesis on graduation may be given as an instance:—It was *On the Architectonicks of Natural Metaphysics.* His studies in voltaic electricity were made chiefly under Ritter, an obscure and mystical writer, though the author of some curious experiments on what were called Secondary Piles; and he at length obtained, in 1806, a professorship in his own university; but his associates appear to have been rather literary than scientific persons, such as Steffens, Oehlenschlager, Niebuhr, and Fichte; he also engaged in controversies of a theological tendency, which, to the end of his life, appear to have had a great attraction for him.

(789.) His first writings on electricity. In 1812 Oersted visited Berlin, and published there a work on Chemical and Electrical forces, tending to prove their identity, which was translated into French by Marcel de Serres. The author afterwards looked back to the period of the publication of this treatise as the dawn of his electro-magnetic discovery. So far as I know of its contents (for I have never seen a copy), it does not contain anything beyond indefinite anticipations of the real identity of electricity and magnetism. In this, indeed, there was nothing new. Compass-needles had been seen to be reversed by lightning; electric shocks had been passed through steel without any certain effect; and Van Swinden had published a work in three volumes expressly on the subject, containing the results of a mass of ingenious failures. Nor, perhaps, can we give Oersted credit, at that early period, for a more distinct apprehension of the relation so anxiously sought for, than was possessed by several of his contemporaries. His belief is said to have been grounded on the notion, that "if galvanism be only a hidden form of electricity, then magnetism *can only* be electricity in a still more hidden form"—a syllogism which, if it satisfied Oersted's metaphysical friends, would hardly be accepted as demonstrative in the laboratory; and, after all, it suggests no one form of relation rather than another.

(790.) His discovery of electro-magnetism. Professor Forchhammer, the friend and pupil of Oersted, states that, in 1818 and 1819, it was well known in Copenhagen that he was engaged in a special study of the connection of magnetism and electricity. Yet we must ascribe it to a happy impulse—the result, no doubt, of much anxious thought—that, at a private lecture to a few advanced students in the winter of 1819–20, he made the observation, that a wire uniting the ends of a voltaic battery in a state of activity, affected a magnet in its vicinity. It was in the fact of the circuit being *closed*, that the main difference consisted between this and previous attempts, in which galvanic pairs or batteries not connected by conductors were expected to show magnetical relations, though, in such a case, the electricity was evidently stagnant.

(791.) Details respecting it. Some mystery hangs over Oersted's apprehension of his own experiment. It seems difficult to believe that he clearly saw its significance. Unlike Davy, when he first saw the fiery drops of potassium flow under the action of his battery, and recorded his triumph in a few glowing words in his laboratory journal, Oersted took no immediate measures either to complete or to publish his discovery. Some months appear to have elapsed whilst waiting for the convenience of a larger battery before he repeated the experiment with the aid of Professor Esmark and other friends. The battery then employed contained 20 twelve-inch elements, charged with water and $\frac{1}{30}$th of mixed nitric and sulphuric acids. The conducting wire was heated red hot, which must have rather diminished the effect than otherwise. The nature of the wire was found to be unimportant. If positive electricity passed from north to south through a conducting wire placed horizontally in the magnetic meridian, then a compass needle suspended *over* it had its north end deviated to the west; if *under* it, to the east; if the needle was placed on the *east* side of the conductor, its north end was raised; if on the *west* side, it was depressed. Oersted further found that needles of non-magnetic substances, such as brass and gum-lac, were not affected, and that the electrical efficiency depended on the quantity, not the intensity, of the current. These experiments seem to have been made in July 1820; and Oersted and his friends being now fully alive to the novelty and importance of the discovery, he circulated extensively copies of a Latin tract, dated the 21st July, in which the effects of the "electric conflict," as he terms the presumed combination of the opposite electricities in the "conjunctive wire" upon a magnet, were described.[1] In this tract we find the following expressions:—"The electric conflict acts in a revolving manner." "It resembles a helix." "The electric conflict is not confined to the conducting wire, but it has around it a sphere of activity of considerable extent."

(792.) Speedily taken up by Ampère, Arago, and Davy.

The effect of this pamphlet, consisting of a few pages only, was instantaneous and wonderful. The author probably counted on the opportunity of developing his discovery at leisure, but it was seized on with such avidity, and pursued with such signal success, particularly in France, that he probably gave up the race of invention in despair. Ampère had already communicated experiments to the Institute on the 18th and 26th September. Arago and Davy separately, and but little later, discovered the magnetizing power which the voltaic conductor exerted on iron filings, and the latter tried in vain the magnetizing power of common or machine electricity, which, however, was soon after shown by Arago, who enclosed steel wires in *helices* of copper wire, through which the discharges were passed. When soft iron was placed in such a helix, it was found to become a temporary magnet of great power whilst the voltaic current continued. Thus magnets of enormously greater power than any previously known were constructed; one of the first large ones was made by Professor Henry of the United States.

(793.) But the progress of electro-magnetismas a science was far more indebted to Ampère, a professor at Paris, than to any other philosopher. I shall, therefore, introduce here some account of his discoveries before closing what I have to say of Oersted.

(794.) Electro-dynamic theory of Ampère.

Andre Marie Ampere was born in 1775 at Lyon. He was an able mathematician, and wrote several memoirs on Chances, and on the Integration of Partial Differential Equations. But with this he combined a taste for, and a practical acquaintance with, the experimental sciences. He was a very good chemist, and showed himself particularly attentive to Davy on his first visit to Paris. He was also much attached to metaphysical speculation. His skill in devising apparatus and in performing experiments was eminently shown in his electro-magnetic researches; whilst he judiciously rendered his mathematical knowledge subservient to them. In this respect he had greatly the advantage of Oersted, who appears to have been little acquainted with mathematics, and, perhaps, in common with his metaphysical friends of the German school, misapprehended their utility in physical discoveries. Three different hypotheses were speedily broached to represent mechanically the singular kind of force mutually exerted between a conductor and a magnet. The first and most obvious was, that this action was not a *push-and-pull* force, but a force producing rotation without direct attraction and repulsion, or of the nature of a *couple* exerted between any part of an electric current, and a small magnet or magnetic element. The second opinion was, that an electric current may be esteemed equivalent to a magnetizing force at right angles to it. The third, that a magnet is composed of elements which act as if a closed electric circuit existed independently within each of them; that is, each magnetic molecule may be replaced by a small conducting wire bent upon itself, in which some unfailing source of electricity, like a galvanic pair, keeps up, in the same direction, a constant current.

Various opinions on the nature of the electro-magnetic force.

(795.) Theory or hypothesis adopted by Ampère.

This last hypothesis, arbitrary and improbable as it may sound, was that defended by Ampère. Whilst few will be disposed to regard it as a true and complete physical picture of the condition of magnetized bodies, it seems impossible not to award to it the same sort of credit which we do to Newton's "fits of easy reflection and transmission" of light, when we find that it not only serves to represent the more obvious phenomena, but has suggested experiments absolutely new, and which turned out in accordance with the anticipation; and that, finally, by the sagacity and industry of its author it was made to include, by merely mathematical deductions, and without any complication of the hypothesis, certain experiments of a very singular kind, which at first seemed inexplicable by it. I proceed to develope a little farther this consideration.

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[1] The exact title was, *Experimenta circa effectum Conflictus Electrici in Acum Magneticum.*

(796.) Mutual action of electric conductors.

The theory of Ampère rejects all but push-and-pull forces, such as are commonly recognized in mechanical physics. These forces are mutual, and belong to electric currents. A permanent magnet is a congeries of minute parallel and circular currents, all acting in the same direction, which is at right angles to the magnetic axis or line of force. Granting this for a moment, Oersted's experiment shows that the current in the conductor acts on the currents in the magnet; and as a magnet places itself transversely to a conductor, the currents in the magnet tend to place themselves *parallel* to that in the conductor. Do we then find such properties in moveable electric conductors alone? Have they any mutual action? Does that mutual action tend to produce parallelism? And if so, may it be farther analysed into direct attractions or repulsions of the several parts of the electric currents upon one another? All these questions were answered by Ampère *affirmatively* after due appeal to experiment. Two copper wires connected with voltaic circuits, and suspended with the requisite degree of freedom, *approach* when the currents have a *similar* direction, but are repelled when the direction is opposite in the two. When two moveable conductors are placed at right angles, or indeed at any angle, they tend to parallelism. All the usual phenomena of a magnet may be imitated by a long helix of copper wire through which electricity is made by some artifice continually to circulate. The position of the poles is the same as in a real magnet, and the *name* of pole is determined by the direction (right or left handed) in which the helix is wound. Such an instrument, not containing one particle of iron, is attracted and repelled by a steel magnet,—obeys the directive influence of the earth,—gives transverse motion to an electric conductor near it,—in short, does whatever magnetized iron does.

(797.) Elementary law of the inverse square of the distance.

Thus, in the mutual action of electric currents (for the phenomena of static electricity are wholly unlike) we recognize the great discovery of Ampère. A new science was formed, which he called *electrodynamics*, which he proceeded to develope with great skill and success. MM. Biot and Savary found that the electro-magnetic force exerted by an indefinite straight conductor and needle, varies inversely as the simple distance from the conductor; but looking to the elementary actions of each portion of the current, it will be found that this corresponds to the usual physical law of the inverse *square* of the distance between the magnetic and the electric element.

(798.) Mr Faraday and De la Rive—Electromagnetic rotations.

Whilst Ampère was pursuing his inquiries into the properties of electric currents, others were varying, in a great variety of ways, Oersted's fundamental experiment. A great number of beautiful mechanical arrangements were invented, particularly by the elder De la Rive and by Mr Faraday. The latter, however, had the sole merit of effecting a most singular kind of motion, that in which a magnet floating in mercury is made to revolve *continuously* around a central conducting wire, and in like manner a conductor may be made to revolve round a fixed magnet; nay, stranger still, a magnet acting at once as conductor and magnet, revolves with great velocity on its own axis when an electric stream is made to traverse one half of its length. These astonishing experiments, which, in an earlier age, might have founded a new sect of astronomers and replaced the theory of Vortices, offered also considerable difficulties in the application of Ampère's theory. They were, however, ultimately removed by Ampère himself, who analysed with great skill the mechanical conditions of each case, and interpreting them into the language of his theory, showed how continuous rotations might be produced, according to the laws which he had established, by electric currents alone suitably arranged; and he effected by most ingenious experimental combinations purely electro-dynamic rotations. Some other experiments, in which magnets seemed to produce a different effect from electro-dynamic cylinders, presented a more serious obstacle, which, however, was removed by a rigorous demonstration of the effects which must ensue, if we regard the elementary molecules of a magnet as very small, and consequently the entire magnet as a collection of indefinitely small and correspondingly numerous electro-dynamic cylinders. By means of four critical experiments, Ampère determined completely the elementary laws of the mutual action of currents, including that previously established by Biot and Savary in the case of a magnet and a conductor. This investigation was one of great intricacy, and was carried out with remarkable skill. Ampère had the field almost to himself, Savary making some contributions; and, what is remarkable, little or nothing has been added either to the theory, or to the deductions from it, since his death. The progress of the science of electro-magnetism has been so astonishingly rapid since the year 1820, that one set of phenomena after another has for the time attracted almost exclusive notice. The discovery of diamagnetism will probably lead to a reconsideration of Ampère's theory as applicable to all matter in a more general form.

Accounted for by Ampère.

(799.) Great merit of Ampère.

This rapid succession of interesting topics has prevented attention from being perhaps sufficiently directed to the importance of Ampère's labours. He is at least as well entitled as any other philosopher who has yet appeared, to be called "the Newton of Electricity."

(800.) His death

Ampère was of an amiable, though rather eccentric character. His absence of mind was proverbial, and his style is somewhat cumbrous and obscure. But he was devoted to science, the promotion of which was ever his first consideration, and he evidently himself possessed great clearness in his conceptions. He died on the 17th May 1836.

(801.) Seebeck. Discovery of thermo-electricity.

Whilst Ampère, Arago, Davy, the two De la Rives, and Mr Faraday, were throwing light on the causes, and developing the consequences of Oersted's experiment, Seebeck of Berlin discovered in 1822 a new source of electric excitement, which has since become indirectly of very great importance. This was Thermo-Electricity. He found that when heterogeneous metals are united, either by soldering or pressure, and the junction heated, a current of electricity is established. The order of metals which produces the most energetic combinations, is wholly unlike the arrangement of the voltaic series, and has no apparent reference to any other known property of those substances. Bismuth and antimony stand at the opposite extremities of the scale, and a *pair* formed of them is consequently the most powerful which can be made. When heated at the junction, positive electricity passes from bismuth to antimony. In 1823, Oersted, then on a visit to Paris, united with Fourier in making experiments on this subject, and was probably the first who constructed thermo-electrical piles. Unquestionably, the most important application of these was to the construction of an instrument for measuring the effects of radiant heat, by Nobili and Melloni, of which an account has already been given, Art. (709).

(802.) Invention of the galvanometer—Schweigger and Nobili.

An application of electro-magnetism of extreme importance, was the Multiplier or Galvanometer, contrived by Schweigger of Halle. In it the idea was first realized of *measuring* the power of an electric current by its effect in deviating a magnetic needle. Schweigger perceived that he could *multiply* the action of one and the same current, by causing it to traverse successive parallel coils of the conducting wire carried round the needle. Its sensibility was still farther, and almost indefinitely increased by Nobili's invention of rendering the needle *astatic*, or diminishing its natural directive power in any required degree. This he did by connecting it firmly with a second needle parallel to the first, of nearly equal strength, with its poles placed in an inverted position relatively to the other, and moving freely in a plane altogether exterior to the coil, so that whilst the directive effect of the earth's polarity is almost neutralized, the electro-magnetic effect of the coil tends to produce a similar deviation in both needles. This is one of the most precious philosophical instruments ever invented. It has been employed for thirty years in almost every electrical research or application. One of its best forms for many purposes (though hitherto little used) is the Torsion Galvanometer of Ritchie.

(803.) Oersted's history continued.

Oersted, of course, interested himself in this new application of his own great discovery. Indeed, having the good fortune to survive that discovery for more than thirty years, with a full enjoyment of his intellectual vigour, he had the gratification of contemplating a body of science entirely new as its results, and a variety of useful applications scarcely less astonishing, which might, in one sense, be called his own creation. The discoveries of Ampère, Seebeck, and Mr Faraday, were all based upon his; and during those thirty years, this elegant and interesting branch of experimental physics underwent an almost uninterrupted extension, such as hardly any other affords an example of. The Electric Telegraph is one of its most direct and practical results; nor should we omit that Oersted himself proposed, as far back as 1818, the application of electricity to blasting rocks by the very same process in which it has of late years been so usefully applied, namely, that of heating a fine wire to incandescence.

(804.) His experiments on the compression of water.

Though Oersted was the author of numerous papers connected with science down nearly to the close of his life, they do not contain any important discovery, and with reference to electro-magnetism, he appears to have contented himself principally with repeating and expounding the observations of his contemporaries. But some of his experiments on other subjects deserve mention, especially those on the compressibility of water. This fact, which the Florentine Academicians had vainly sought to establish in the 17th century, had been clearly demonstrated by Canton in the middle of the 18th, but Oersted first devised a compendious and effective apparatus for producing and measuring it more effectually. His result, that the compression amounts to 46-millionths of the bulk, for a pressure equal to one atmosphere, agrees almost precisely with Canton's. In 1845, he considered that he had established that the heat developed by the same amount of compression is ·0203 of a centigrade degree. He also made some experiments on the Law of the Compressibility of Air and upon other subjects.

(805.) Oersted receives the prize of the Institute of France.

The *desideratum* of a clear expression of the manifest alliance between Electricity and Magnetism had been so long and so universally felt, that the discovery placed its author in the first rank of scientific men. There was not even, so far as I am aware, a suspicion that he had been, however remotely or dimly, anticipated. The prize of the French Institute which had been awarded to Davy for his galvanic discoveries, was bestowed upon Oersted, and so far as I am informed, has not been since adjudicated. He was elected first Correspondent, and finally Associate of the Academy of Sciences. He was personally known to many of the philosophers of Europe, having made repeated journeys in France, Germany, and England. His agreeable manners and general information rendered him popular. Sir H. Davy, who visited him at Copenhagen, describes him as "a man of simple manners, of no pretensions, and not of extensive resources." Niebuhr, however, who viewed his character in a different light, says, "I scarcely know another natural philosopher with so much intellect, and freedom from prejudice and *esprit de corps*." His writings were indeed too discursive. Professor Forch-

His scientific character.

hammer has enumerated above 200 of his publications or articles, on a vast variety of subjects; but of all these, only a single tract of a few pages will perhaps be ultimately remembered. As I before remarked, his mind, though capable of continued application, appears to have wanted the sort of concentration which prolonged physical researches require, and the school of philosophy in which he was considered by his own countrymen as a proficient, has never been fruitful in researches based on Induction.

(806.) His death.

In November 1850, the fiftieth anniversary of his connection with the University of Copenhagen was celebrated by a jubilee. Though in his 74th year, his activity was unimpaired, and he continued his lectures and other employments until within a few days of his death, which occurred on the 9th of March 1851, closing a life full of years and honour.

§ 5. Dr Faraday.—*Progress of the Theory of Electro-Chemical Decomposition—Volta-Electric Induction—Magneto-Electricity—Diamagnetism—Optical Changes induced by Magnetism.*—Professor Plücker—*Magneoptic Action.*

(807.) Eminent discoveries of Dr Faraday.

Immeasurably the larger part of what we know with regard to the nature and laws of electricity and of its connection with Magnetism, so far as it has been developed since the discovery of Oersted, is due to the genius and perseverance of one man—Michael Faraday.

(808.) His early history, and connection with Davy and the Royal Institution.

This eminent philosopher was born, I believe, in 1791. He was originally "a bookseller's apprentice,—very fond of experiment and very averse to trade." In 1812 he sent to Sir H. Davy, then at the height of his reputation, a copy of a set of notes taken at his lectures, desiring his assistance "to escape from trade, and enter into the service of science." To the credit of the popular and distinguished chemist, he gave Mr Faraday a courteous answer, and appointed him as chemical assistant in the Laboratory of the Royal Institution in March 1813. Leaving England to travel in the autumn of the same year, Davy engaged Mr Faraday to accompany him as secretary and scientific assistant; they returned in April 1815, and from that time to the present Mr Faraday has been constantly engaged in the scientific business of the Royal Institution, which is as completely associated with his numerous and splendid discoveries as Cambridge is with those of Newton, and Slough with those of the elder Herschel. By a rare, perhaps unexampled good fortune, that establishment, founded principally for the promotion of original research and the promulgation of discoveries, has been indebted during the first *fifty years* of its existence to the talents of two men only, for a succession of new scientific truths which might have done credit to a whole academy; indeed, if to the names of Davy and Mr Faraday we add that of Young, who here first promulgated the doctrines of the Interference of Light, there is scarcely an academy in Europe which has within the same period added so extensively to our choicest stock of original science.

(809.) Variety of his publications—his *Researches on Electricity.*

Partly in consequence of his official duty of bringing forward and explaining the most important cotemporary discoveries, partly also in consequence of his own matchless talent of elucidating, by original illustrations, if not by new facts, whatever he undertakes to expound, the variety of subjects on which Dr Faraday has made essential additions to our knowledge is so great that it is difficult to comprehend them under one section. In conformity, however, with our plan of suppressing minor facts, and insisting on the most important, I shall confine myself to a summary statement of his main discoveries connected with Electricity and Electro-Magnetism as contained in a continuous series of "Researches," published in the Philosophical Transactions between 1831 and the present time; which, when collected (as they have been in a distinct form), now fill three closely printed octavo volumes. It would be difficult to name in the history of any progressive experimental subject so large an amount of research prosecuted for so long a time in so methodical a manner and with such remarkable uniformity in plan, and with such unvarying success.

(810.) Electro-magnetic rotations.

I shall only farther premise that Dr Faraday's earliest essays were naturally of a chemical character. In 1820 he assisted Davy, in prosecuting Oersted's researches on the relations of Electricity and Magnetism, and the following year he himself succeeded in producing, for the first time, the continuous rotation of a magnet round an electric conductor, and the converse rotation of the conductor round the magnet (798). These experiments were the germ of others which continued to interest philosophers as well as the curious public for a long time after. But it was in 1831 (when the author had attained his 40th year) that the genius of Dr Faraday was displayed in a commanding manner by the appearance of his First and Second series of the *Researches on Electricity*, which have not perhaps been surpassed by even the most brilliant of their successors. The subject was the Induction of Electric Currents from other Currents and from Magnets. But we shall find it most convenient to take an order different from that of the discovery, and to present the main results of Dr Faraday's electrical labours under the following heads:—

Heads of his chief electrical and magnetical discoveries.

I. The law of definite Electro-chemical Decomposition, and the theory of the pile connected therewith.

II. The Induction of Electric Currents from other

Currents and from Magnets, or the discovery of Magneto-Electricity.

III. The influence of the Magnet on all bodies, and the consequent division of substances into two classes, Magnetics and Diamagnetics.

IV. Optical changes induced by Magnetism.

(811.) Electro-chemical decomposition, and theory of the pile.

I. With regard to *electro-chemical decomposition and the theory of the pile*, the great extent and intricacy of the subject require us to restrict our analysis to a few of the leading conclusions. The most important of these may be summed up in the following propositions :—1*st*, The amount of a decomposable substance (or *electrolyte*) analysed into its elements by a current of electricity depends *solely* on the amount of electricity passing through it, and is independent of the form of apparatus employed, the dimensions of the poles (or *electrodes*), the strength of the solution, or any other circumstance. It is thence inferred, with respect, for instance, to water, that the amount of it decomposed in a given time is an exact measure of the quantity of electricity set in motion in that time. 2*d*, When a substance is thus decomposed, it is a necessary, or at least a highly probable, consequence of Dalton's laws, that the elements separated are in atomic proportions to one another. But Mr Faraday also found that when several decompositions are effected at the same time by interposing different electrolytes in intervals of the same circuit, the whole of the series of elements separated bear the atomic relations to one another. Thus, to take a single case ; an electric current decomposes in the same time 0·497 grain of water and 3·2 grains of protochloride of tin. Now, these are exactly the proportions of the atomic weights of those bodies. From this and numerous other cases Mr Faraday infers, that universally the amount of electrical action required to dissolve a combination is in a constant proportion to the force of chemical affinity by which its elements are united. The corollary seems therefore highly probable that it is one and the same force which is exerted in either case. But the conclusion as to their identity becomes almost irresistible when we add to these propositions the following: 3*dly*, That the oxidation of one atom of zinc by the acid of the battery generates precisely so much electricity as would resolve one atom of water into its elements. Thus, 8·45 grains of zinc dissolved occasioned the analysis of 2·35 grains of water ; but these numbers are in the ratio of 32·5 to 9 ; the equivalents or atomic weights of zinc and water.

Definite character of decomposition—electrical equivalents.

(812.) Inferences as to the identity of electrical and chemical forces.

From these strictly experimental laws, Dr Faraday considers that he is entitled to draw these important inferences : *First*, that the source of voltaic electricity in the pile is chemical action solely; *Secondly*, that "the forces termed chemical affinity and electricity are one and the same."[1] It is needless to add that these conclusions, involving the very essence of the science of voltaic electricity, are supported by Mr Faraday by a great variety of collateral proofs ; and, on the whole, I cannot see that they admit of any reasonable doubt. The contact theory of Volta still, however, holds its ground in Germany, where the number of influential writers on electricity is considerable ; and so perseveringly is it maintained, that it is difficult to perceive how it is ever to be dislodged. But on this wide and not very profitable controversy we cannot here enter.

(813.) Dr Faraday on Induction and Conduction.

There are a great many other considerations connected with the action of the voltaic battery which are independent of these primary ones, and which are scarcely less important. Dr Faraday has entered into a most elaborate experimental argument to show that *induction* always precedes both *conduction* and *decomposition*, and that decomposable bodies or electrolytes must be all more or less perfect conductors. His views may be thus concisely summed up in his own words :—"The first effect" of the electrifying influence, whether of frictional electricity or of voltaic electricity, upon bodies, is "the production of a polarized state of their particles which constitutes *induction ;* and this arises from its action upon the particles in immediate contact with" the excited body, "which again act upon those contiguous to them, and thus forces are transferred to a distance. If the induction remain undiminished, perfect insulation is the consequence ; if the contiguous particles" thus polarized "have the power to communicate their forces, then conduction occurs, conduction being a distinct act of discharge between neighbouring particles." "In the inductive condition assumed by water" when about to be decomposed, "the discharge between particle and particle is not, as before, a mere interchange of their powers and forces, but an actual separation of them, the oxygen travelling in one direction and carrying with it its amount of force acquired during polarization, and the hydrogen doing the same thing in the other direction, until they each meet the next approaching particle, which is in the same electrical state with that they have left, and by association of their forces with it produce discharge. This action may be regarded as a *carrying* one performed by the constituent particles of the dielectric."[2] Again, "the current is an indivisible thing ; *an axis of power*, in every part of which both electric forces are present in equal amount."[3]

(814.) These views respecting the molecular progress of conduction and decomposition, though perhaps never so categorically stated as by Dr Faraday, have been, I imagine, substantially held by a majority of those who have considered the subject since the time of Davy, who first gave them a partial expression. And when Davy and others speak of the electric forces in decomposition as if they *emanated* from the poles of the battery and became enfeebled with distance from them, they used a language not quite rigorous indeed, yet expressing the actual phenomena with that general accuracy which we can alone expect in the first stages of so new and difficult an inquiry. "The sum of chemical decomposition is constant for any section of a decomposing conductor" is Dr Faraday's expression.[1] So is the sum of illuminations arising from light radiating from a point, when taken across any section of its path, yet the influence is said to vary inversely as the square of its distance from the origin. The part of Dr Faraday's conclusions, however, most open to exception, is what refers to electric action at a distance, which he conceives to depend *solely* upon induction acting on intervening particles, which induction *may* take place along curved lines. It is indeed true that he has shown, by a beautiful experiment, that the interposition of different substances between an excited electric and a body capable of being electrified by induction, occasions different degrees of excitement in the latter, even when the interposed bodies are glass, sulphur, and other "non-conductors;" and this he justly refers to a peculiar power or property of bodies called "specific inductive capacity." But this is rather different from the general proposition above referred to.

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[1] *Researches*, Art. 918.

[2] Ib., Arts. 1338, 1347.

[3] Ib., Art. 1642.

(815.) Uniform nature of electricity from whatever source.

In conclusion of this part of the subject, I must add that Mr Faraday has, with great pains and success, demonstrated the fundamentally identical nature of electricity from whatever source derived, and however differing in its usual manifestations;—such as electricity of the pile, of the common machine, or that induced by magnetic, thermal, and animal electricity. These have all common properties, producing the shock, the spark, and magnetic, chemical, and heating effects; and, except two, also producing sensible attraction and repulsion. But the disproportion of the effects of electricity, varying so much in intensity when referred to unit of quantity, is astonishing and paradoxical. The electricity which so silently and speedily decomposes a single grain of water would, when its intensity is sufficiently exalted, produce, according to Mr Faraday, "a very powerful flash of lightning," or 800,000 times the contents of a well charged Leyden battery. Again, zinc and platinum wires half an inch long and one-eighteenth inch diameter, dipped into slightly acidulated water, produce in three seconds as much electricity as a man can easily bear in the form of a shock.

(816.) Induction of electric currents—magneto-electricity.

II. *Induction of electric currents from other currents and from magnets.*—This splendid research, which dates from 1831, constitutes the discovery of *magneto-electricity.*

The discovery by Ampère of the attraction and repulsion of conductors conveying electric currents rapidly followed (as we have seen in Art. 796) Oersted's discovery of the power of electricity to affect the magnet, and the corollary from it of the magnetizing agency of electricity. This being achieved, very striking analogies led to the expectations—1. That a wire conveying a current ought to excite by induction a current in another wire near it; and, 2. That a magnet ought, under some circumstances at least, to be capable of exciting electric action. But attempts in these directions had repeatedly and signally failed, and for a reason which Mr Faraday first rendered apparent.

(817.) Volta-electric induction.

Having made a compound helix of two copper wires wound parallel to one another, but not touching, and rolled one within the other upon a cylinder, he found that when he transmitted a continuous voltaic current through one wire, a *momentary* current (tested by a galvanometer) took place in the independent helix in the same direction with the primary current; but it ceased to exist instantaneously, although the primary current continued to act; and it was only on the cessation of that current that a new *momentary* induced current appeared, but in the contrary direction to the previous one. The same effect occurred when a wire conducting a current was mechanically brought into the presence of another wire; the approximation of the two induced a similarly directed current, their separation a contrary effect. Whilst the wires were immovable no induced current took place. This he termed *Volta-Electric Induction.*

(818.)

Mr Faraday next took a ring of soft iron, disposing two copper-wire coils round opposite portions of the ring. In passing a current through one coil, and thus magnetizing the ring, a current was induced in the other copper coil, but, as in the former case, only for an instant. When the primary current stopped, and the magnet was *unmade*, an opposite current shot through the secondary coil.

(819.) Magneto-electricity.

The transition to the next experiment was natural, but highly important. The primary coil was suppressed; and the piece of soft iron embraced by the secondary coil was now magnetized by the inductive action of a powerful bar magnet, with which contact was alternately made and broken. At the instant of making contact a momentary current of electricity was produced in the remaining coil, and on breaking it a reversed current, also of instantaneous duration. No current existed whilst the magnet continued to be applied. The direction of the current at *making* contact was *opposite* to that which would have produced the magnetism present in the iron core; on *breaking* contact the current was *similar* to that which would have magnetized the iron. The electricity momentarily induced in the coil was tested by its action on the galvanometer, by its power to magnetize steel, to convulse a frog, and finally by the production of a spark. This, then, was the discovery of *magneto-electricity*.

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[1] *Researches,* Art. 504.

(820.) The mere motion of a permanent magnet was now substituted for the induction of magnetism in soft iron. By pushing one end of a bar-magnet into the coil, electricity was developed so long as the motion continued; on withdrawing it an opposite current took place. Even the feeble magnetism of the earth induced a sensible electric current in a wire moved transversely to the direction of the dipping-needle.

(821.) Arago's rotation-magnetism explained. By making a copper plate revolve in the neighbourhood of a powerful magnet, a continuous current of electricity may be detected passing from the centre to the circumference of the plate, and may be collected by proper means. Here, then, is a *magneto-electric machine*. This current perpetually present in a conducting plate revolving beneath a magnet, cannot fail (by the common laws of electro-magnetism) to react on that magnet. Dr Faraday showed in the most satisfactory manner that its action is exactly what is required to explain M. Arago's experiment of "transient magnetism by rotation"—namely, to cause the magnet (if free) to follow the direction of motion of the plate (515).

(822.) On the whole, this research of Dr Faraday may be cited as one of the most original and admirably conducted which the annals of science present, and as such may be usefully recommended to the student.

(823.) Dr Faraday's discovery of diamagnetism. III. *The influence of the magnet on all bodies, and their consequent division into two classes; Magnetics and Diamagnetics.*—By many, perhaps most persons, this will be regarded as the greatest of Dr Faraday's discoveries. It dates from 1846. By using electro-magnets of very great power, and suspending bodies of a somewhat elongated form between the poles, he has proved that every substance, *solid*, *liquid*, or *gaseous* which he has put to the test, is either drawn into a line joining the poles of the magnet, as soft iron would be, returning to that line if displaced, or else it settles in a position at right angles to this, or across the line of poles. The former he calls paramagnetic or simply magnetic bodies, and their position *axial;* the latter diamagnetic bodies, and their position *equatoreal.* Bodies may be arranged in a list commencing with those most paramagnetic, diminishing to neutrality, then feebly diamagnetic, and finally the strongest diamagnetics. The following is such a list of a few solid and liquid bodies thus classified:—

Classification of magnetic and diamagnetic bodies.

Magnetics or Paramagnetics......	Iron. Nickel. Cobalt. Manganese. Palladium. Crown glass. Platinum. Osmium.
Zero	Vacuum.
Diamagnetics	Arsenic. Ether. Alcohol. Gold. Water. Mercury. Flint glass. Tin. "Heavy glass." Antimony. Phosphorus. Bismuth.

(824.) Fundamental experiment and definition of diamagnetism. The equatoreal pointing of diamagnetic bodies evidently presupposes that they are longer in one dimension than in the others. A small bar of silicated borate of lead, or "heavy glass," about two inches long, and from a quarter to half an inch broad and deep, suspended in a stirrup of paper by six or eight lengths of cocoon silk, was the apparatus first employed by Dr Faraday. When a sphere or a cube is used, of course it cannot point. The diamagnetic action is shown in that case by the little body *being repelled indifferently from either pole of the magnet*, in the same manner as soft iron is indifferently attracted by either. This repulsive tendency includes the phenomenon of equatoreal pointing, and its law is thus comprehensively expressed: "The diamagnetic tendency is to move the body from stronger to weaker places of magnetic force."

(825.) Farther illustrations. The behaviour of diamagnetics in the presence of a magnet may be thus further illustrated. It is what would occur if a body absolutely inert were suspended in a fluid pressing upon it, that fluid being at the same time more or less magnetic, that is, more or less attracted by *either* pole of the magnet. The result would evidently be, that the body would seem to be repelled, and would set equatoreally for the same reason that a piece of wood plunged in water rises to the surface as if repelled by gravity. Thus Dr Faraday suspended feebly paramagnetic bodies in ferruginous solutions more magnetic than themselves, when they acted as diamagnetic bodies would do.

(826.) It is impossible for the most part to guess beforehand to which class a substance will belong. China-ink, porcelain, silkworm gut, shell-lac, and charcoal, rank amongst paramagnetic substances; whilst sulphur, resin, wood, leather, and most animal substances, are diamagnetic. Thus, if a living man could be delicately enough suspended between the poles of a huge magnet, he would settle equatoreally.

(827.) Discussion on the nature of diamagnetism. Philosophers are not yet entirely agreed as to the precise nature of the Diamagnetic relatively to the Magnetic actions of bodies. Besides Dr Faraday, MM Weber and Edmond Becquerel abroad, and Professors Tyndall and William Thomson in this country, have examined the subject both practically and theoretically in great detail. The more probable opinion seems to be, that bismuth and its analogues acquire a true polar condition under the action of magnets, but opposed to that which iron and paramagnetics do in like circumstances.

(828.) Obscure anticipa- by Brugmans and Lebaillif.

Like almost every other great discovery, some feeble traces of this may be found amongst the voluminous records of almost forgotten experiments. Brugmans observed, in 1778, the repulsion of bismuth by a magnet, which was rediscovered by Lebaillif in 1827; and something like the equatoreal pointing of shell-lac and wood was noticed in the same year by Becquerel, and may also be traced in the writings of Coulomb. The present writer recollects very distinctly to have had pointed out to him by M. Becquerel, at Paris, about 1835, the pointing of minute chips of wood placed near a common steel magnet. But these incidental facts having been suffered to remain in complete obscurity for so many years, without even an attempt to connect and explain them, can scarcely be said even to touch the originality of Dr Faraday's discovery.

(829.) Father Bancalari discovers the diamagnetism of flames.

The year after the announcement of diamagnetism, Father Bancalari of Genoa discovered the powerful diamagnetic quality of *flame.* It is easily shown by placing the flame of a wax taper between two blunt conical terminations of a powerful electro-magnet. The flame spreads equatoreally, becoming *fish-tailed.* Dr Faraday, zealously taking up the inquiry, proved that this depends upon hot air being diamagnetic *relatively* to the surrounding cold air, but that atmospheric air is always *absolutely* paramagnetic. Analyzing the effect still farther, he found that the oxygen of the air is a very powerful paramagnetic, whilst nitrogen is *relatively* diamagnetic, but in all probability is a neutral substance, one at the real zero of this singular scale. By a most ingenious application of the torsion balance, he was enabled to compare the relative actions of magnetism on the gases with admirable skill and precision. (*Philosophical Transactions*, 1851.)

(830.) Dr Faraday on the magnetism of oxygen.

These experiments demonstrate a paramagnetic (or iron-like) attraction in oxygen really astonishing. A small mass of oxygen appears to be attracted at the distance of an inch from the axial line of the electro-magnet by a force equal to its own weight! Since heat diminishes this quality, the acute perception of Dr Faraday rapidly entertained the idea that the apparent magnetism of the earth might partly at least reside in the atmosphere, and that the changes of terrestrial magnetic intensity and direction might be explained by the action of the sun expanding the atmosphere. The 26th series of his researches is devoted to an elaborate exposition of this theory, which, however ingenious, is still involved in great difficulty.

(831.) Professor Plücker on magne-optic force.

Professor Plücker—Attraction and Repulsion of Optic Axis of Crystals.—Soon after Dr Faraday's discovery of diamagnetism, Professor Plücker, of Bonn, announced the important fact, that the optic axis of Iceland spar is repelled by the magnet. A sphere of that substance suspended by a thread, and having its axis horizontal, being placed between the poles, notwithstanding the perfect symmetry of external figure, the axis ranges itself in the equatoreal position. In some other crystals the axis is directed in the line of poles. The law of the phenomena is not yet completely made out; but so strong is the latter quality in crystals of kyanite, that a piece of that substance properly suspended will actually show a directive power under the influence of the earth's magnetism.

(832.) Magne-crystallic force.

Probably closely allied to this fact is a similar directive tendency observed in well crystallized specimens of bismuth, antimony, and arsenic. This M. Plücker calls the *magne-crystallic*, as the former may be termed the *magne-optic force*; and it is often so intense as to oppose and even reverse the directive tendency which the body would have had between the poles in its massive or uncrystallized state.

(833.)

It will be easily conceived that the interest created by these admirable discoveries, revealing not only new and general properties of matter, but also relations between very different branches of science, soon became general, and raised the reputation of Dr Faraday to the very highest rank as an experimental philosopher. If we compare his two greatest works, that on magneto-electricity, and this on diamagnetism, we find in the former perhaps a more perfect specimen of inductive sequences; in the latter, facts more independently novel and unlooked-for, and an unrivalled skill in the application and invention of experimental methods.

(834.) Dr Faraday on optical changes induced by magnetism.

Passing over many less important matters, there yet remains one interesting discovery to be mentioned, which in point of time preceded the last, namely—

IV. *Optical Changes induced by Magnetism.*—In his 19th Series of *Researches*, published in 1845, Dr Faraday announced "The Magnetization of Light and the Illumination of the Magnetic Lines of Force,"—a title which, though intended to express exactly the author's idea of his discovery, perhaps excited undue anticipations in the public mind. For here we have no direct, or even apparently direct, action of the magnetic force on a luminous ray, but only that a peculiar state is induced by magnetism in some transparent bodies which produces an action on light which they did not possess before, and which, indeed, differed in some respects from any similar action previously recognised.

(835.) Rotation of plane of polarization of a ray of light.

Dr Faraday's leading experiment is the following:—A piece of "heavy glass," or siliceous borate of lead, was placed lengthwise between the poles of a powerful electro-magnet. A ray of plane-polarized light was transmitted through the glass parallel to the line of the magnetic poles; when the magnetic energy was fully applied, the plane of polarization of the light was found to have twisted round, similarly (apparently) to what occurs when polarized light passes through quartz or oil of turpentine. It is found that a great number of solids and liquids are subject to the magnetic influence in the same manner as in the case of "heavy glass," though to a smaller amount.

(836.) Resembles the action of quartz, but with a difference.

Now, in reasoning on this experiment, it is to be observed that no rotation of the ray takes place unless there be a *medium* on which the magnetism impresses its energy.[1] Some molecular change, no doubt, results, such as that which pressure gives to glass, rendering it doubly refracting and depolarizing, or, to take a still closer analogy, when heat applied to it conveys similar properties. Yet no one imagines that these experiments show a direct reaction of heat, still less of mechanical compression, upon light. Yet, with all abatements, Dr Faraday's discovery is novel and singular; the more so, that this constrained state differs from that naturally possessed by quartz and certain liquids. The state magnetically induced in a body causes the rotation of the ray to be reversed when it moves in the contrary direction; that is, its rotation is right-handed when the ray moves from the north to the south pole, but left-handed when it moves from S. to N. But in bodies in the natural state the rotation takes place towards the same hand whatever be the path of the body. Mr Airy has shown that this peculiarity admits of being mathematically expressed in a manner somewhat analogous to that imagined by Professor MacCullagh in the case of quartz (512); but it is not pretended that these formulæ convey information as to the physical conditions on which these singular phenomena depend.

(837.) Dr Faraday liquefies certain gases.

Amongst Dr Faraday's contributions to science not connected with electricity, the most remarkable perhaps is the condensation of many gases into the liquid form by cold and pressure, of which he is the undoubted discoverer. This fact is highly interesting both in a scientific and practical point of view. In the latter it was early applied by the late ingenious Sir M. I. Brunel as a new moving power (375), and it may not improbably yet be resorted to for that purpose. The subsequent discovery of a mode of solidifying carbonic acid by M. Thilorier is not only interesting in itself, but affords a method of producing more intense cold for experimental purposes than any other previously known.

(838.) His wide reputation.

Dr Faraday still continues his laborious and fruitful inquiries. Whilst he has attained almost every titular honour which the world of science has to bestow (including that of associate of the French Academy of Sciences), he has preserved a modesty of character and a simplicity of life which enhance the respect in which he is held by all who are admitted to his nearer acquaintance. No one has more successfully escaped the contentions which literary rivalry so often produces; and by his extraordinary skill in expounding the most difficult researches, whether made by himself or by others, he has maintained (as I have already said) the early reputation of the Royal Institution, and has immensely enlarged the circle of those who are able to admire and appreciate his successes.

§ 6. Ohm—Daniell—Mr Wheatstone—M. Jacobi.—*Laws of Electrical Conduction;—Constant Battery;—Applications of Electricity to Telegraphs—Clocks—Motive Engines—the Electrotype.*

(839.) Vast detail of the science of electricity. Its numerous cultivators.

We have traced in the last section the progress of electrical and of electro-magnetic discovery since the days of Davy and Oersted, as well exemplified in the pre-eminent researches of Dr Faraday. In conformity with the plan of this Dissertation (13), (14), I have, on account of their immense interest and importance, analyzed them more fully than could possibly have been done were I to render similar justice to *all* who have distinguished themselves in the same career. Thus, France has produced in M. Becquerel one of her most ingenious and indefatigable experimentalists, full of devotion to science, and giving up conscientiously the whole of a long life to the cultivation of this particular department. His discovery of the efficacy of long-continued and very feeble voltaic actions to produce crystallized earthy and metallic compounds not obtainable by chemical means is highly important. Switzerland is proud of her two De la Rives,[2] and Italy of not a few disciples of Volta. In Germany the number of electricians is greater than in any other country; and as they have taken the lead in obtaining correct *measures* of the electric forces, and in determining (in many cases) the numerical laws which regulate the efficiency of batteries and conductors, and have applied these to many important practical purposes, I shall devote a section to some account of these, as well as to the beautiful experiments of our countryman Mr Wheatstone.

(840.) Ohm's theory of electrical conduction

Ohm's *Law of Electrical Conduction.*—Georg Simon Ohm was born in Bavaria in 1787, and was successively professor at Cologne, Nürnberg, and

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[1] I may here record that before the year 1835, I suspected that there might be some immediate action between circularly polarized light and a magnetized body, and made experiments in consequence in May 1836, which, however, led to no result. I rather think, however, that these experiments deserve careful repetition under more varied circumstances.

[2] MM. Becquerel and A. De la Rive have both published elaborate works on Electricity, to which the reader is referred for details on this inexhaustible subject.

Munich. He died on the 7th July 1854. His theory of electrical conduction was not highly appreciated in Germany until it had received, in 1841, an eminent mark of approval from the Royal Society of London, by the award of their Copley medal. His principal work on the Galvanic Circuit (*Die galvanische Kette mathematisch bearbeitet;* Berlin, 1827) has had a somewhat peculiar fate. Accepted by only a few persons as a great discovery, it met with comparatively little attention, at least until recently; yet notwithstanding the long anticipation by Ohm of his results, it has been his misfortune to have their originality contested.

(841.) Its merits and defects.

It seems not difficult to account for the diversity of estimation in which this work has been held. The primary fault is the author's own. He deduces the strength of a voltaic current in any given circuit, and the electroscopic excitement of each part of the circuit, by means of reasoning seemingly *a priori*, from certain assumed axioms submitted to mathematical reasoning. The axioms are very simple; the theory founded on them is intended to correspond to Fourier's theory of heat, of which, indeed, in point of form, it is a mere and literal copy; but as every circumstance which introduces real complication is soon left on one side, the leading propositions are almost self-evident results of the axioms. In short, the parade of mathematics is uncalled for, and the whole structure of the theory seems so slight and questionable that one is surprised that it should ever have been regarded as more than a clever expression of some approximately true experimental laws. It appears, indeed, that this is the simple fact;—that the axioms *were* obtained from the results which they seem to predict, and that Ohm was an experimentalist before he became an author. In this guise we understand how to treat the so-called "Laws of Ohm." They are truly important empirical laws, calculated to guide the practical man in applying and measuring galvanic forces, to enable the theorist to form clearer notions of the different (often confusing) effects of these forces, and to reduce their varying energy to calculation; but we must be allowed to doubt whether Ohm has thrown any new light on the *real* first axioms of electrical excitement or transmission.

(842.) The principal laws of conduction.

The most important of these laws refer to the numerical measure of the voltaic stream circulating in the conductor of a closed circuit. Such a closed circuit may be imagined to consist of—(1.) an excitor or battery; (2.) a conductor homogeneous or otherwise, but necessarily continuous, uniting the ends of the battery. The *exciting force* is derived (we will assume) from the chemical or thermo-electric action present in the battery. The electric equilibrium being disturbed, is restored more or less speedily through the medium of the conductor which connects the poles. If the conductor be good, the electricity passes rapidly through it, and does not accumulate in the battery; if the reverse, it accumulates until it acquires power to overcome the resistance, and then it passes through in a stream less abundant, but of a higher intensity. If the construction of the battery does not permit that degree of intensity to be reached, the electricity stagnates in the battery, the conductor cannot perform its office, no effect results. The whole maybe compared to a spout of water discharged into a trough, from the bottom of which extends a long narrow horizontal pipe. The water is the electricity, the trough is the battery, the pipe is the conductor. If the pipe be *very* long and narrow, no water at all will pass through it until the water in the trough has attained a certain height, or has a *head* of pressure sufficient to overcome the resistance in the pipe. If the trough be filled to the brim without the resistance being overcome, the trough is as good as plugged, no motion takes place, the stream regurgitates. The longer the pipe the feebler the stream that passes; shorten the pipe indefinitely, and the efflux depends only on the construction of the trough. Indeed, the illustration might be pushed considerably farther. The *depth* of the cistern represents the electro-motive force of the voltaic combination; its area the size of the plates. By increasing the latter, we do not give the means of overcoming more resistance; but when the resistance is small, we afford a larger supply without lowering the level—*i. e.*, the intensity.

Illustration.

(843.) Resistances estimated.

Ohm regards the current as proportional to the electro-motive force directly, and to the resistances inversely; and the latter are divided into (*a*) the resistance of the battery itself to the passage of the current; (*b*) the resistance of the conductor. Now the latter *varies as the length of the wire completing the circuit.* We may therefore double its amount by doubling the length of wire joining the poles; and if we observe the strength of the current passing before and after this has been done, we have a measure of $a+b$ in the first experiment, and of $a+2b$ in the second; and b being assumed to be known, a, or the comparative resistance within the battery, becomes known also.

(844.) Standard of resistance.

The resistance of a standard copper wire a foot long may be taken as the unit of resistance. Mr Wheatstone finds it convenient to assume a copper wire a foot of which weighs 100 grains. M. Jacobi prefers a mètre of copper wire one millimètre in diameter. The resistance is as the length, and inversely as the sectional area.

(845.) Force of the current—tangent compass.

To measure the current two methods have chiefly been used, and the results agree closely. One is the *tangent compass.* A voltaic current is allowed to pass through a thick wire arranged in a vertical circle. At the centre of the circle is placed a *very short* magnetic needle. When a current passes the needle is deflected; and it is easy to show that the deflecting forces are as the tangent of the angle of deflection. A double or treble force in the circuit produces a deflection of the needle whose tangent is double or treble the first.

(846.) Voltameter. The other method is by Dr Faraday's *Voltameter.* The amount of water decomposed is directly as the quantity of the current. The unit in this case is one cubic centimêtre of gas produced from water in a minute.

(847.) These two measures agree. After being once compared, we may in all cases deduce the decomposing force of a current from its effect upon a tangent compass.

(848.) Rheostat of MM. Wheatstone and Jacobi. Mr Wheatstone has facilitated the measurement of voltaic effects by the invention of the rheostat, a simple contrivance for introducing any desired length of wire into a circuit, and thus estimating resistances both of conductors and of batteries, and also the electro-motive forces of different batteries. The results appear to be extremely satisfactory. (*Phil. Trans.*, 1843.) The conducting power of different metals drawn into wire will be inversely as the lengths required to be introduced into the circuit to reduce the strength of the current in a given proportion. The principle of the rheostat was independently applied to similar inquiries by M. Jacobi of St Petersburg, in 1840.

(849.) Farther deductions from Ohm's theory. The laws of Ohm farther proceed to expound the effect of the size and number of the elementary cells combined in a voltaic battery. The size of the plates increases the quantity of electricity which escapes through a *short* conductor, but has little effect upon a long current. On the other hand, the multiplication of elements produces no increase in the voltaic stream when the connecting wire is short and when it is also a good conductor, for the chief resistance in the circuit is in that case the battery itself, which resistance increases with the number of elements, just as the force which overcomes it increases. If, on the other hand, the chief resistance be extraneous to the battery, the addition of more elements increases the power without much increasing the resistance. All this scarcely requires mathematical proof. It is very evident, and very just, and it is borne out by experiment.

(850.) Ohm's theory farther gives the partial effects of a current branching into various unequally good conductors, and into other details, particularly as to the electric tension in different parts of a circuit. It is, however, to be observed, that the whole is based on the assumption that *the dissipation of electricity from the surface of the conductor is insensible.*

(851.) Fechner's experiments. It is only justice here to add, that the theory of Ohm owes much, if not most, of its value to the experiments of Fechner in Germany; and that its reception in France and England is mainly due to the ingenious and (in many cases) independent experiments of M. Pouillet and Mr Wheatstone.

(852.) John Frederic Daniell—the constant battery. Daniell's *Constant Battery.*—This seems the proper place to mention an invention which has exercised a remarkable influence on the progress of practical electricity—I mean the Constant Battery. I believe that the merit of this application is entirely due to the late Professor Daniell,[1] although the German writers (who manifest throughout a singular sensibility with regard to their national claims to electrical improvements) seem to claim it for their countrymen. Every battery previously constructed diminished rapidly in energy from the instant of being charged. This was chiefly due to two causes; first, to the acid becoming gradually charged with oxide of zinc; and, secondly, to the appearance of "nascent" hydrogen arising from the decomposition of water at the copper surface where it prevented effectual conduction of the electricity. These sources of diminished effect were prevented in the following way:—Instead of a single cell containing one fluid moistening both the copper and the zinc, a double cell was formed by means of a partition of bladder or porous earthenware. The partition next the zinc was filled with dilute sulphuric acid; the partition next the copper with a solution of sulphate of copper, also acidulated. When galvanic action proceeds, both fluids are decomposed; but whilst that in the zinc cell becomes charged with oxide of zinc, it is at the same time continually acidulated by the electro-chemical transfer of acid from the decomposition of sulphate of copper in the copper cell; and the copper set free from the same combination in the form of oxide is metallically reduced by combining with the "nascent" hydrogen (the oxygen derived from the water decomposed having combined with the zinc), and the metallic copper is deposited in an ever fresh film on the surface of the copper plate. This beautiful invention was described in 1836. Many other batteries on the same principle have been since contrived and described; several are more powerful, but none perhaps are so constant in their action.

(853.) Application of electricity to the arts. *Application of Electricity to the Arts*—MM. Wheatstone *and* Jacobi.—I have selected Messrs Charles Wheatstone and M. H. Jacobi as the representatives of a numerous class of ingenious men who have shown great felicity of invention in applying ingenious mechanism to render electric agency available in the arts. We here again find the reciprocal influence of art upon science, to which I have elsewhere adverted (32, &c.) The requirements of practice are magnificent experiments, such as no individual and no scientific Society would think of executing for the illustration of theory. It is not in the least my purpose to transfer to these two gentlemen an exclusive merit which they need not be unwilling to share with other energetic and able competitors in the hard-run race of scientific applications. They occupy, however, perhaps the most marked and distinguished place, and the field is so wide and includes so many minute details, that it requires all our resolution to fix our eyes steadily on the most considerable acquisitions—the nobler sheaves of so prolific a harvest.

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[1] John Frederic Daniell, Professor of Chemistry in King's College, London, was born in 1790. He was the author of a work on *Chemical Philosophy*, of *Meteorological Essays*, and of numerous papers in the *Philosophical Transactions*, many of which were connected with Voltaic Action. His work on Meteorology contributed materially to the progress of that science, as did the invention of his Hygrometer (notwithstanding certain defects in that instrument) to the theory and practice of Hygrometry. For his Constant Battery Mr Daniell received the Copley medal of the Royal Society. His death took place from apoplexy while attending a council meeting of the Royal Society on the 13th March 1845.

(854.) I shall connect, then, with the name of Mr Wheatstone, (1), the apparatus for determining the velocity of electrical conduction, (2), the electric telegraph and clock,—with that of M. Jacobi, (3), electrodynamic machines, and (4), the electrotype.

(855.) Mr Wheatstone on the velocity of electric conduction.

I. The apparatus used by Mr Wheatstone in 1834 for measuring the velocity of the passage of the electrical impulse through a good insulated conductor such as a copper wire, deserves particular notice from its great ingenuity, and from its general application to the measurement of short intervals of time. Let a copper conducting wire of half a mile long be so convoluted that the middle and the two ends of the wire may be brought near together, the whole being perfectly insulated. Let the wire be slightly interrupted at these three places, and the whole put into connection at pleasure with an electric machine or battery. When contact is made, three sparks will take place. Let the two end sparks be called A and C and the middle one B. As the three sparks take place close to each other, they can easily be seen at once reflected in a small plane mirror. Let now this small mirror be put in very rapid rotation round a horizontal axis so placed that the sparks (if they occur in the suitable part of the revolution) may be reflected together to the eye. Imagine the rotation to become immensely rapid:—in Mr Wheatstone's apparatus the velocity reached 800 times in a second; consequently the mirror described 1° in $\frac{1}{800 \times 360}$th part of a second; *i. e.*, in $\frac{1}{288,000}$ of a second. But for 1° of rotation of a mirror the reflected image will describe an arc of 2°. Supposing then that all the sparks occur at the same absolute instant of time, they will be seen in one line (supposing the points of the interrupted circuit in a line), but if either spark occur later than the others by only $\frac{1}{288,000}$ of a second, the mirror will have revolved so much in the interval as to displace the image of that spark relatively to the others by the very palpable angular amount of 2°. In the copper wire half a mile long, the *end* sparks occurred simultaneously, whilst the *middle* spark occurred later by about one millionth of a second; giving a velocity of transmission (according to Mr W.) of 288,000 miles a second, or somewhat greater than that of light.[1] The velocity in an *iron* telegraph-wire, ascertained lately in America with much greater accuracy, and by a different method, is only 16,000 English miles a second; but doubts have been thrown upon the correct interpretation of these experiments. Those of M. Fizeau on the telegraphic lines of France give results more conformable to Mr Wheatstone's, namely, about 70,000 English miles per second for iron, and 120,000 for copper wire. The duration of a spark drawn immediately from the battery is insensible, but in Mr Wheatstone's experiment it lasted $\frac{1}{24,000}$ of a second when transmitted by a copper wire half a mile long.

(856.) Electric telegraph—its early history.

II. *Electric Telegraph and Clocks.*—The idea of using the transmission of electricity to communicate signals is so obvious as hardly to deserve the name of an invention, the prodigious velocity of common electricity in wires having been established by Watson before the middle of the last century. The earliest proposal of the kind appears in the *Scots Magazine* for February 1753, where a correspondent from Renfrew, who signs himself C. M., proposes several kinds of telegraphs acting by the attractive power of electricity, conveyed by a series of parallel wires corresponding in number to the letters of the alphabet, and insulated by supports of glass or jeweller's cement at every twenty yards. Words are to be spelt by the electricity attracting letters, or by striking bells corresponding to letters. One Lesage, in 1782, and even long before, *proposed* to convey twenty-four insulated wires in a subterranean tube, and to indicate the letters of the alphabet by means of the attraction of light bodies. In 1811 Sömmering suggested a similar application of voltaic electricity, chemical decomposition being the effect observed. Oersted first, and then Ampère (1820) suggested the use of magnetic deflections for the same purpose, which is nothing else than the needle telegraph in general use in England; but they contented themselves with the suggestion merely. MM. Gauss and Weber communicated signals at Göttingen in 1833 or 1834 to a considerable distance, and gave them the signification of letters. This was the first accomplishment of telegraphic communication by means of electricity, and it realized the fancy of Strada, quoted by Addison, of sympathetic magnets. It was, however, a mere appendage to a magnetic observatory, and its application and diffusion on a great scale seems to have required a distinct effort; for several years elapsed before we hear more of the telegraph.

(857.) Telegraphs of MM. Morse, Steinheil, and Wheatstone.

The year 1837 is the date of the realized electric telegraph. We find three distinct claimants, of whose independent merits there is no reason whatever to doubt, though how much of the merit of all must be considered due to MM. Gauss and Weber, who first made the experiment, though they did not offer it for general adoption in a convenient form, is a matter which we need not here decide. The three independent inventors (I name them alphabetically) are Mr Morse of the United States, M. Steinheil of Munich, and Mr Wheatstone of London. The telegraph of the two last resembles in principle Oersted's and Gauss's; that of the first is entirely original, and consists in making a ribbon of paper move by clockwork, whilst interrupted marks are impressed upon it by a pen or stamp of some kind brought in contact with the ribbon by the attraction of a temporary magnet, which is excited by the circulation of the telegraphic current of electricity. In the telegraphs of MM. Wheatstone and Steinheil the needle moves only to the right or left; and by the combination of a certain number of right and left motions, either with one or with two independent needles acted on at once by distinct currents, the alphabet is easily, though somewhat tediously constructed. Such, however, is the dexterity which practice gives, that forty or even more of such complex signals are transmitted and registered per minute.[1]

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[1] The numerical value is of course only a very rude estimation.

(858.) It has already been said that we claim the exclusive invention of the electric telegraph for no one individual. But of the several inventors none probably has shown such perseverance and skill in overcoming difficulties as Mr Wheatstone.[2] His telegraph accordingly was in general use in England before M. Steinheil was able to obtain a similar success in Germany. The telegraphs of Mr Morse are naturally preferred in America, and they have this inestimable advantage, that they preserve a permanent record of the despatches which they convey.

(859.) The earth-circuit. There is one circumstance connected with the electric telegraph deserving of particular notice—I mean the apparently infinite conducting power of the earth when made to act as the vehicle of the return current. Setting all theory aside, it is an unquestionable fact, that if a telegraphic communication be made, suppose from London to Brighton, by means of a wire going thither, passing through a galvanometer, and then returning, the force of the current shown by the galvanometer at Brighton *will be almost exactly doubled*, if, instead of the return wire, we establish a good communication between the end of the conducting wire and the mass of the earth at Brighton. The whole resistance of the return wire is at once dispensed with! This fact was more than suspected by the ingenious M. Steinheil in 1838; but, from some cause or other, it obtained little publicity; nor does the author appear to have exerted himself to remove the reasonable prejudices with which so singular a paradox was naturally received. A most ingenious artist, Mr Bain, established for himself the principle, and proclaimed its application somewhat later; and in 1843, perhaps the first entirely convincing experiments were made by M. Matteucci at Pisa. From this time the double wire required to move the needle telegraph was reduced to a single one. The explanation of this curious fact appears to be,—not that the electricity is conducted back by the earth to its origin at the battery,—but that the molecular disturbance polarly communicated along the conducting wire to its farther end being effectually relieved by perfect communication with a vast reservoir of neutral electricity like the earth, conduction proceeds in an uninterrupted manner, and to an unlimited extent.

(860.) Submarine telegraph. Of submarine telegraphs, it is sufficient to state that the isolation is obtained by inserting the conducting wires in a mass of gutta percha, and that the first on a considerable scale was sunk between Dover and Cape Gris Nez, on the French coast, in August 1851.

(861.) The applications of electricity to the measurement of time are so numerous, that I can only refer generally to the principal contrivances.

(862.) Electric clock. 1. The simple electric clock of Mr Bain derives its maintaining power from two large plates of copper and zinc (or more simply zinc and charcoal) sunk in the earth, which affords for a very long time a continuous supply of voltaic electricity. The current is conveyed into the bob of the pendulum, where it traverses a long coil of wire; and as the pendulum oscillates, the current (by a simple shifting contrivance) is reversed at each vibration. A *stationary* bar-magnet is placed so that when the pendulum moves, the voltaic coil of the bob embraces the magnet, and the direction of the current is such as by the electro-magnetic reaction to strengthen and maintain the vibratory movement, which is by this means perpetuated.

(863.) Sympathetic clocks. 2. Sympathetic clocks.—By means similar to those just explained, one standard clock anyhow regulated may, by means of magneto-electric currents, convey absolutely isochronous movements to any number of affiliated clocks at any distance. Probably the first application of the kind was made by M. Steinheil.

(864.) American electric-registration clocks. 3. American electric-registration clocks.—Mr Locke proposed to register the instant of an event occurring in the following way: A ribbon of paper being put in uniform motion, as in Morse's telegraph, a dot is imprinted on it every second by means of a simple connection with an astronomical clock. A separate marking apparatus under the control of the experimenter enables him to interpolate a dot or mark corresponding to the instant of any event happening—such, for instance, as the transit of a star. This method has the great advantage of leaving the observer at entire liberty to watch the object without having to attend to the beats of the clock, whilst it renders mistakes next to impossible. It has been successfully applied to the determination of longitudes, and more recently to all kinds of astronomical observations, by Mr Bond in America, and by Mr Airy at Greenwich (231).

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[1] Occasionally 18 or 20 *words* per minute have been telegraphed.

[2] I ought to mention that the practical introduction of the electric telegraph in England is in no small degree due to the energy of Mr Fothergill Cooke, joint patentee with Mr Wheatstone for the invention. The question of the respective shares of these gentlemen in the merit of telegraphic communication was submitted, in 1841, to the arbitration of Sir Marc Brunel and the late Mr Daniell, the result of which appears to leave the preponderance of merit in some respects ambiguous; nevertheless, in a history of Science, Mr Wheatstone is clearly entitled to the pre-eminent place. Several pamphlets have also been subsequently published by the parties. It is significant that Mr Cooke admits having borrowed his idea from becoming acquainted, at Heidelberg, in March 1836, with Gauss's experiments.

(865.) Chronoscopes. 4. Chronoscopes, or instruments for the measurement of excessively short intervals of time, such as the flight of military projectiles, and even the transmission of sensation and motion along nervous fibres.—Such instruments have been constructed on a great variety of principles. Those of M. Pouillet, Mr Wheatstone, and Mr Siemens, deserve especial mention.

(866.) Electro-magnetism as a prime mover. III. Of electro-magnetism used as a moving power, we need say little. No one can witness the astonishing experiment of the sudden creation of magnetic power sufficient to sustain one or two tons by the voltaic dissolution of a few grains of zinc, without having the idea suggested of a continuous moving force. This enormous power is, however, exerted through a space so excessively minute, that its dynamical effect is always small; and, though it is, of course, possible to produce an engine by a sufficiently gigantic arrangement, the success has hitherto not been encouraging.

(867.) M. Jacobi's machines. The rotations of Mr Faraday and Dr Ritchie were electro-dynamic machines on a small scale. They were (probably) first mechanically applied by M. dal Negro in 1833, but more systematically by Mr. M. H. Jacobi, of St Petersburg, the following year. It is stated that the latter gentleman moved a boat on the Neva with an electro-dynamic motor equivalent to three-fourths of a horse power. He has also investigated the theory of these machines, and the most advantageous circumstances of their employment. The principle is the alternate attraction and repulsion of two temporary magnets (one of which revolves), the current of electricity being suddenly changed at the critical part of the revolution.

(868.) Electrotype or Voltatype; —MM. Jacobi and Spencer. IV. To M. Jacobi—almost simultaneously with Mr Spencer of Liverpool—we are also indebted for one of the simplest and most elegant applications of electricity, the Galvano-plastic art, or Voltatype. In this, advantage is taken of the perfectly metallic state in which the base of a metallic salt is deposited at the negative pole of a voltaic combination. In the case, for example, of the decomposition of sulphate of copper, the sulphuric acid unites with the positive wire, or remains suspended, while the metallic copper is slowly and homogeneously deposited on the surface of any object (rendered conducting by the application of black lead or otherwise), of which it forms a perfect mould, from which a fresh cast or *fac-simile* in metal of the original object may be obtained by a repetition of the process. To see the veins of a leaf, or the delicate wing of an insect, thus metallized, is certainly an astonishing thing; and the applications to the useful arts are far too numerous to be noticed here. Daniell's invention of the Constant Battery evidently suggested the Voltatype.

§ 7. CAVENDISH—COULOMB—*Experimental Laws of the Distribution of Statical Electricity;—Mathematical Theory of the same.*—POISSON—*Mathematical Theory of Statical Electricity and of Magnetism generalized.* Green; Professor William Thomson.

(869.) Statical theory of Electricity. Having thus brought down the history of galvanic or voltaic electricity, and that of the wonderful discoveries connected with it, to our own time, I shall in this section briefly notice the more intermitting progress during the same period of our knowledge of the quantitative laws which regulate the distribution of statical electricity on bodies charged with it.

(870.) Æpinus, Cavendish, and Coulomb. "Æpinus and Coulomb," says Dr Whewell,[1] "were two of the most eminent physical philosophers of the last century." They laid the foundations of an exact science of statical electricity; and a third, and still more eminent name, deserves to be connected with theirs,—that of CAVENDISH, of whose general labours I have already given some account in the Second section of the chapter on Heat. The labours of Æpinus belong rather to the period embraced in the previous Dissertation, where they have been referred to by Sir John Leslie.

(871.) Cavendish's theory and experiments. Perhaps the most elaborate of the memoirs not strictly chemical which Cavendish published were those on electricity. The Franklinian hypothesis of a single fluid in excess or in defect of its average state producing the phenomena then known as electrical, offered a tempting field to an experimental philosopher well trained in the mathematical knowledge of the day; and his paper on this subject shows extreme care in its conception and execution. He assumes, as a matter of necessity, the repulsion of matter for matter at sensible distances, considered apart from the electricity always combined with it in greater or less quantity. The indifference of matter under ordinary circumstances is held to arise from the union with it of a sufficient amount of electricity to neutralize the repulsion of the matter. In short, the electric fluid is considered as a second kind of matter repelling its own particles, and attracting those

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[1] *History of the Inductive Sciences*, vol. iii., p. 34, 2d edition.

Cavendish's electrical theory and experiments.

of other matter with a force varying inversely as some less power of the distance than the cube. Common matter repels its own particles and attracts electric particles according to the same law. The limitation as to a power below the inverse cube of the distance is necessary, since were the decrease of force more rapid, a particle would not be sensibly affected by the repulsion of any portion of the fluid except what was placed close to it. The hypothesis of Cavendish and his mode of reasoning from it were in general the same as those of Æpinus; but Cavendish was not aware of the researches of the Swedish philosopher until his own memoir was completed. The number of facts accurately ascertained concerning electricity was at that time too small to admit of very precise numerical comparisons, but the ordinary cases of attraction, repulsion, and induction, were perspicuously explained by the theory; and had the inverse square of the distance been assumed (as it very safely might have been) to represent the law of diminishing repulsion, several of the theorems would have assumed a much more definite character, as was shown by Robison. Cavendish first demonstrated in his paper of 1771 that electricity must be confined close to the surface of a spherical body. This memoir also includes a correct theory of the Leyden phial, a just approximation to the law of attraction as the inverse square of the distance, a theory of conduction, and of the distribution of electricity on insulated conductors placed at a distance but connected by a fine wire or electric canal; and it was only the prelude to other researches never published, but of which some remarkable fragments exist amongst his manuscripts. Professor William Thomson, who has partly examined these, informs me that they contain the experimental solution of problems such as the following: "To compare the quantities of electricity on a spherical conductor, and a plane disk of equal diameter connected by a long conducting wire." Cavendish found that the sphere holds 1·57 times the electricity of the plate, a result *exactly* coincident with the deductions of theory.

(872.) He makes an artificial torpedo.

I may here (for the sake of biographical connection) mention Cavendish's paper on the Torpedo, as a remarkable instance of the explanation of an obscure natural phenomenon, by the analogous effects of an artificial imitation. The experiments of Walsh on the Electrical Fishes have been cited in the preceding Dissertation. Cavendish undertook the bold task of proving, that all the external effects of the shock under varied circumstances, might be reproduced by a combination of Leyden jars duly protected. He made an artificial torpedo, consisting of 49 jars in a frame covered with leather, and he succeeded in obtaining shocks in air as in water, exactly comparable to those obtained from the live fish by Walsh. But perhaps the most striking part of the paper is the incidental mention of several laws of electricity then certainly new, and which he had deduced from experiment. Thus, he affirms the conducting power of iron for electricity to exceed 400,000 times that of distilled water, which he states to be equivalent to the fact, that a conductor of equal diameter will transmit as much electricity if the iron be 400,000 times *longer* than the water—a law conformable to that of Ohm. He farther estimates the conducting power of sea-water at 100 times, but of saturated brine at 720 times that of pure water. Again, the quantity of electricity required to raise the charge on different jars or plates to the same intensity he finds to be directly as the area of the coating, and inversely as the thickness of the plate, and he applies this just conclusion with great ingenuity to explain the surprising power of the torpedo's shock by the extreme fineness of the membranes separating the columns of the electrical organs.

(873.) Coulomb's electrical experiments.

Coulomb (born 1736, died 1806[1]) was a person of less genius and less mathematical attainment than Cavendish, yet he had very considerable geometrical ability and much facility in applying it to the results of experiments, which he conducted with the greatest ingenuity and accuracy. In the latter respect he has seldom been surpassed. His methods, and even his numbers, are still, after a lapse of more than half a century, in many cases the best we can quote. Like Cavendish, he was devoted to *quantitative* estimations of phenomena.

(874.) The balance of torsion and the proof plane.

His two greatest inventions were the *balance of torsion* and the *proof plane*. In the course of his strictly mechanical researches (which, as we have seen in the chapter on Mechanics, Art. 339, &c., were numerous and important) he ascertained the laws of torsion. Within the limits of perfect elasticity, he found that the force is as the angle of torsion of the wire or fibre, and inversely as its length. An almost indefinite minuteness may thus be attained in the measure of forces which may be balanced by the elastic torsion of a wire. We have seen (Astronomy, § 1, Art. 156) how it was applied by Michell and Cavendish to measure the gravitation of bodies. Coulomb's invention dates at least from 1784. By means of it he established (in a different and perhaps more satisfactory way than had been done by Robison in 1769) that the electric and magnetic forces vary according to the Newtonian law;[2] and with the aid of the "proof plane" he obtained exact measures of the electric tension on any part of an excited body. The "proof plane" consists of a small gilt disk with an insulating handle, which being applied *flat-wise* to the surface of an excited body takes off a portion of electricity, which is found in all cases to be proportioned to the electric excitement of the part which it had touched; being then presented to the torsion balance properly electrified, it shows by the repulsive effect produced, the relative tension of the part of the body whence the *sample* was obtained.

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[1] For a farther account of Coulomb, see the chapter on Mechanics, § 2.

[2] Besides this law, Coulomb experimentally proved two others of great importance:—1. That the electricity of an electrified conductor resides wholly on its surface. 2. That the interior of such a conductor is in a condition absolutely undisturbed by the presence of other external excited bodies.

(875.) Results. In this manner Coulomb determined the distribution of electricity upon electrified spheres at and after contact with one another;—on spheres inductively electrified,—on rods and plates and other figures; and his results, so far as they have been compared with theory, give evidence of the care and skill with which they were obtained, allowance being in all cases made for the loss of electricity by imperfect insulation. He also laboured with praiseworthy diligence to compare his results with the theory which he adopted of *two* fluids, each attracting the particles of the other and repelling their own according to the Newtonian law. The Æpinian theory admits of only one fluid, but as it assumes a repulsion between the elementary particles matter it cannot be said to gain much in simplicity, whilst the mathematical results of either hypothesis are in general the same. M. Mosotti has endeavoured recently to revive the view of Franklin and of Æpinus, so as to include, after the manner of Boscovich, the entire mechanical properties of matter.

(876.) Theory of electrical attractions and repulsions. The doctrine of attractions is a complex and difficult one even when the distribution of the attracting matter, as well as the fundamental law of attraction, is known. But it becomes much more so when the distribution of the attracting matter is itself the result of the very effect which it is the object of the problem to discover. If two homogeneous spheres attract one another, molecule to molecule, by the law of gravity, the problem is easy, provided the matter be rigid, and the distribution of it therefore unchanged; but if two such spheres be charged with the mobile electric *fluid* (using the term as a mere abbreviation), the case is very different, for now the electricity tends to shun the nearest points of each sphere, and to accumulate itself towards the remoter parts of their surfaces. The distribution of the electricity, and also the repulsive effect at any point, are both to be found simultaneously. The calculations of Coulomb were inadequate (as has been said) to such a solution; he contented himself with computing the effect of certain simple distributions which evidently lay on opposite sides of the truth, and comparing them with the result of experiment. Though any one such comparison might avail little, the cumulative evidence of many imperfect comparisons argued favourably for the truth of the hypothesis.

(877.) Its principles developed by Coulomb, At the very time that Coulomb was pursuing this inquiry, Legendre first, and then Laplace, were inventing and improving those subtle and powerful mathematical methods at which we have glanced in the chapter on Physical Astronomy, Art. 99, &c., for estimating attractions by a general method. Legendre's principles of calculation applied to cases of the symmetrical distribution of the attractive substances, but Laplace escaped this restriction. The problem is reduced to finding a quantity usually denoted by the letter V, called by some writers the *potential*, for the given body or surface, the expression for which may in each case be expanded into a series, the co-efficients of the terms of which (known as Laplace's co-efficients) are connected by certain relations which are evolved from the conditions of the problem. It was M. Biot first of all, but principally Poisson, who applied this method to electrical, and subsequently to magnetical phenomena. Poisson, with great labour, succeeded in representing correctly by analysis the conditions of some of Coulomb's experiments on spheres and ellipsoids. But it must be owned that the complication of the analysis, the difficulty of applying it to any but the very simplest cases, and the considerable latitude of the errors of experiment, rendered the results rather analytical exercises than solid bases for physical induction; which may in some degree account for the manner in which Sir John Leslie mentions them in his Dissertation. Poisson (as I have elsewhere remarked) had not the talent of conducting his mathematics in a fertile direction, and usually left the fields of experimental physics on which he touched nearly as barren as he found them. But this is no reason why other mathematical reasoners may not obtain more pregnant results. We shall see in the next section that Gauss, a distinguished contemporary of Poisson, by treating the great problem of the distribution of the magnetism of the globe (in many respects similar to those of the theory of electricity) with the utmost mathematical generality, has obtained results of great novelty and importance; that he has not only shown experimenters how to proceed, but has invented instruments for them to use. A similar step has not yet been taken in electricity. Notwithstanding the unquestionable beauty of Sir William Harris's methods of measuring electrical attractions (*Phil. Trans.* 1834), they are little adapted for comparison with theory, and Coulomb's experiments still remain the standard ones on the subject.

Laplace, and Poisson.

Potential.

(878.) Writings of Green and of Professor W. Thomson. The theory of Coulomb has, however, been ably generalized by Green, a nearly self-taught mathematician of great originality, who died at a premature age. In a memoir on electricity privately printed about 1830 he generalized Poisson's methods and applied them to a number of new cases. His paper was reprinted a few years since in Crelle's Journal. To him I believe is due the term *potential.* Several continental mathematicians of eminence have added some steps to the theory of electricity, but probably the most important from its fertility and simplicity is a theorem discovered by Professor William Thom-

Electrical images.

son of Glasgow, for reducing the electrical effects of electrified spheres upon points or other spheres without them to those of electrified points in certain positions replacing the spheres, which points, from certain analogies to well known optical formulæ, Professor Thomson has designated *electrical images.*[1]

(879.) Application of the theory of magnetism to correct ships' compasses. MM. Barlow and Airy.

The mathematical theory of magnetism has received a highly practical application in the correction of the deviation of compass due to the local attraction of ships. Professor Barlow of Woolwich led the way in attempting practically to correct the errors thence arising. But when ships began to be constructed almost entirely of iron, the use of his "correcting plate" was found to be totally insufficient. To the Rev. Dr Scoresby, practical navigation is indebted for many ingenious observations on the magnetism of ships, and suggestions as to the means of allowing for it; while Mr Airy and Mr Archibald Smith have the merit of applying the Theory of Magnetism to the case in question. Mr Airy's investigations may be found in the *Philosophical Transactions* for 1839 and 1855; from which it appears that the effects of local magnetism in a vessel may be speedily and effectually corrected for a given place by the use of two permanent magnets placed in rectangular positions relatively to the compass; and by the use of a mass of soft iron in a third direction. But grave doubts still remain as to the possibility of rendering such corrections permanent, and applicable in all magnetic latitudes. A great step has, however, been gained by putting the power of readily verifying the compass corrections in any part of the world in the hands of every intelligent captain.

§ 8. Professor HANSTEEN—Baron A. VON HUMBOLDT—GAUSS—Major-General SABINE—Captain Sir J. C. ROSS.—*Progress of our Knowledge of Terrestrial Magnetism in the present Century.*

(880.) Recent history of terrestrial magnetism.

I could hardly have intentionally selected a more characteristic example of the scientific progress of the nineteenth century than the recent history of terrestrial magnetism, even had it not accidentally formed the closing section of this Dissertation. The combination of extended methodical research in obtaining physical data, with mathematical skill in comparing them and in deducing from them the most important results, has been attended with merited success. I regret that the unforeseen extent of this historical sketch compels me to touch with great brevity on the leading points of this research.

(881.) Professor Hansteen—*Magnetismus der Erde.*

Variation or declination.

Professor CHRISTOPHER HANSTEEN, of Christiania, in Norway, is the person who has given probably the greatest impulse in recent times to the efforts to methodize the facts and laws of the earth's magnetism. M. Hansteen was born 26th September 1783, and is Professor of Astronomy in the University of Christiania, and Director of the Observatory. His dissertation, entitled *Magnetismus der Erde*, published in 1819, which received a prize from the Royal Danish Academy, recapitulated all the authentic facts obtained by voyagers and others from the earliest times. It will be recollected[2] that Halley had represented the magnetic variation at different parts of the globe by lines traced on Mercator's chart, and passing through all places where the variation (or declination) of the needle from the true north was equal; and being well aware of the progressive (or secular) changes in the course of these lines, he proposed the hypothesis of two pairs of magnetic poles interior to the globe, of which one pair revolves slowly.

(882.) Halley's hypothesis. Variation charts.

Line of No Variation.

This hypothesis, little thought of at the time, and perhaps of little value except as a help towards the formal representation of the facts, appears to have been revived by Wilcke, a Swede, whose labours attracted the attention of Professor Hansteen first in 1807. M. Hansteen found the results of his own collections to coincide well with Halley's chart for 1700, and also with the hypothesis of four poles, two in each hemisphere, one stronger than the other. It results from these charts that the *Line of No Variation*, which, in 1600, formed a remarkable arch-like curve, stretching from the Gulf of Mexico to near the North Cape of Norway, then descending through Central Europe to the Gulf of Guinea, had, during the seventeenth and eighteenth centuries, become gradually flattened (having passed through Paris in 1669, and through London twelve years earlier), and at present this part of the line of No Variation is confined to the American continent and neighbouring seas. Another and more complicated branch of the same line traverses the Pacific Ocean, making a complex serpentine track through Eastern Asia and Siberia. The line of No Variation may be expected to pass through those points of the earth's surface towards which the needle converges, which are sometimes called the magnetic poles (of which more presently), and of which M. Hansteen concludes the position to be as follows :[3]—

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[1] *Cambridge Mathematical Journal*, 1850.

[2] See Fifth Dissertation, p. 741.

[3] From M. Hansteen's *recent* paper on the Secular Change of the Dip (*Copenhagen*, 1855). In this ingenious memoir it is inferred, with considerable plausibility, that the annual diminution of the dip is *decreasing*, and consequently that a minimum of dip will occur in Europe before the close of this century.

Position of magnetic centres or poles.

	Dist. from Pole of Earth.	Long. E. from Greenwich.	Annual Variation in E. Longitude.
N, or strongest northern pole (N. America), for 1838	25° 22′	280° 19′	$+15'{\cdot}5$
n, or weakest northern pole (Siberia), for 1829	7 57	114 33	$+43{\cdot}4-0'{\cdot}153(t-1608)$*
S, or strongest southern pole (S. from Australia), for 1845	21 9	131 28	$-4{\cdot}0$
s, or weakest southern pole (S. from Tierra del Fuego), for 1842.	13 53	216 26	$-16{\cdot}5$

* t denotes the current year. This result appears very uncertain. It gives about $+6'{\cdot}5$ of annual change at the present time. The latitudes of these "points of convergence" are also varying.

Variation maps of a different kind have been constructed by the French Admiral Duperrey, in which the actual direction of the needle is represented by arrows. The above positions of the magnetic poles were deduced by Mr Hansteen from the apparent convergency of the magnetic needle towards those four points. The earlier observations appear to be more precise than might have been expected.

(883.) Lines of dip. Professor Hansteen also constructed charts of the lines of equal dip. In certain positions between the tropics the dip is nothing, or the freely suspended magnetic needle remains horizontal. The line connecting these places is called the magnetic equator. It is an undulating line inclined somewhere near 12° or 13° to the terrestrial equator, and cutting it in two points not exactly opposite, but in about 3° 20′ and 174° 30′ of east longitude from Paris, according to Admiral Duperrey's observations in 1825. The position of these nodes is, however, variable. The north end of the needle (as is well known) dips more and more in the northern hemisphere, until in a certain place it becomes vertical, where therefore the horizontal component of the magnetic force is nothing, and the common compass loses altogether its directive power. Similar phenomena occur in the southern hemisphere. Lines of dip of 10°, 20°, &c., may be drawn, and where the dip is 90° *there* is a true magnetic pole. The best observations seem to show that there is but *one* such true pole in each hemisphere.

(884.) North American pole. If we define as "pole" a spot where the needle points vertically (which is the signification adopted by Gauss and others), these points do not coincide with those of greatest intensity. On the 1st June 1831, Commander Ross (now Sir James Clark Ross) attained the true magnetic pole in the North American continent in lat. 70° 5′ 17″ N., and long. 96° 45′ 48″ W. The dip of the needle was sensibly 90°.

(885.) Magnetic intensity. A third element not less important than Variation and Dip, though more lately brought into notice, is the Intensity of the earth's magnetism, and to this Professor Hansteen directed special attention. That the intensity of the earth's directive force may be measured by counting the oscillations of a suspended magnet in the same way that a pendulum measures gravity was known to Graham, Lambert, and others, towards the middle of the last century; but the exploration of its variation on the earth's surface was first attempted by the officers of Lapérouse in 1785, and later by De Rossel. But it was Baron Humboldt who, at the instigation of Borda,[1] undertook the earliest observations which have had any permanent influence on this branch of science, and who in the first years of this century determined the relative intensity of the earth's magnetism at Paris and at the magnetic equator in South America, to be in the ratio of 1·3482 to 1·0000;[2] a result which has become, so to speak, classical, and which the author considered as the most important result of his journey.[3] M. Hansteen promoted the same enquiry extensively; he devised a neat and convenient apparatus for counting the oscillations of the needles, and he investigated the effects of time and temperature in altering their magnetism.[4] He made numerous observations in the north of Europe, and finally undertook, between 1827 and 1829 (by the liberality of the Norwegian parliament or *Storthing*), an adventurous journey into Siberia, for the purpose of examining the "region of convergence" of the needle in that quarter. His account of his journey has most unfortunately not been published; but his companion, Professor Adolphe Erman, has given the main results, together with extensive observations entirely his own.[5] This was the first magnetical expedition of any magnitude, and of a national character. It yields in importance to none which have succeeded it.

Baron Humboldt's unit.

M. Erman.

(886.) Distribution of intensity. The magnetic intensity then increases from the neighbourhood of the equator towards the Arctic Regions, and there it has two foci of greatest intensity. A similar arrangement occurs in the southern hemisphere, and these four points of maximum attraction or convergence of the needle constitute the "poles" of Halley and of M. Hansteen. To M. Hansteen we are indebted for the first good approximation to a general chart of the lines of equal intensity.

(887.) Diminution of magnetic intensity with height. The supposed diminution of the magnetic intensity as we recede from the earth's surface has been repeatedly made the subject of experiment. The insulated experiments of Gay-Lussac in a balloon (630), and of M. Kupffer at Mont Elbroutz, led to no conclusive result. From a numerous series of careful observations made in the Alps and Pyrenees with Hansteen's apparatus, and studiously corrected for temperature, the present writer has found a diminution of one-thousandth part in the horizontal intensity for a vertical ascent of about 3000 feet.[1]

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[1] See *Kosmos*, vol. i., note 159.

[2] On the same scale the intensity at London is 1·3720.

[3] See *Kosmos, ubi. sup.*

[4] *De Mutationibus Virgæ Magneticæ*, 1842.

[5] See his Lines of Equal Variation, reproduced in the Royal Society's "Report on Physics and Meteorology, 1840."

(888.) Variations of magnetic elements. Such are the general features of the distribution of the magnetic force upon the surface of the globe. But from an early period the magnetic elements for the same place have been known to be variable. Such deviations from constancy are either—1. Secular; 2. Periodic; 3. Irregular. All the three magnetic elements (Variation, Dip, and Intensity) probably partake of these changes.
—1. Secular. The westerly Variation or Declination had till 1818 been increasing in Europe since the earliest observations. This results from a complicated movement of the line of No Variation and its companion curves. While their common centre or pole in North America has been slowly advancing towards the East, a considerable portion of the system of curves in this quarter of the globe has been proceeding in a south-westerly direction nearly in a line joining Spain with South America, thus producing a complicated rotatory motion of the lines of Variation, of which the first effect was to extinguish the singular loop in the curve of No Declination (including a space of easterly declination) which is shown in M. Hansteen's chart for 1600 to have occupied a large part of Western Europe.[2] About 1818 the needle began to retrograde towards the east in this part of Europe. The dip has been diminishing in Europe since the earliest observations.

(889.) —2. Diurnal. Graham discovered the Diurnal Variation of the Compass. It occurs in a reversed direction in the southern hemisphere. Near the equator (as at St Helena) the needle partakes at one season of the northern character, at another of the southern, depending on the position of the sun.

(890.) —3. Irregular. To Baron Humboldt and to Arago we are principally indebted for a knowledge of great and capricious fluctuations of the magnetic elements occurring simultaneously over vast regions of the earth. These have been called magnetic storms.[3] They are often connected with auroral appearances.

(891.) Next to Professor Hansteen, science is mainly indebted for the recent great extension of our knowledge of the facts and laws of terrestrial magnetism to two illustrious German philosophers, Baron Alexander von Humboldt and the late Professor Gauss.

(892.) Baron Alexander von Humboldt. The name of ALEXANDER VON HUMBOLDT is as widely known as science is cultivated. The ardour of his love of nature, the comprehensive interest which he takes in every department of knowledge, and the generosity of his disposition, in combination with the fortunate accidents of an unusually vigorous constitution, and an eminent social position, have combined to place him in the foremost rank of natural philosophers.

(893.) His early history and travels. He was born on the 14th September 1769, and consequently is now (1856) in his 87th year. He was a pupil of Werner in 1791, and devoted considerable attention to metallurgy. An early longing for foreign travel seems to have foreshadowed his future career, but political circumstances were, towards the close of the last century, eminently unfavourable to its accomplishment. His celebrated journey to Southern and Central America (undertaken after the failure of several other schemes) lasted from June 1799 until August 1804. We may, perhaps, be allowed to regret that an impression of the duty of presenting to the public the results of that interesting journey in their most complete form should have absorbed the leisure of so many of his most vigorous years, and should have withheld him from other and still more important enterprizes. From 1808 to 1826 Baron Humboldt resided mainly in Paris, in the most intimate companionship with Arago, who, though much his junior, has predeceased him. He then took up his residence at Berlin, in compliance with the wish of the King of Prussia, and he soon after delivered there a course of public lectures on Physical Geography which formed the basis of his remarkable work entitled *Kosmos*, the composition of which has formed the chief occupation of his vigorous old age. In 1829 he made a rapid but interesting journey into Asiatic Russia, important in its results, yet imperfectly carrying out the ardent aspiration of his early years to unfold the marvellous physical peculiarities of the Eastern continent.

(894.) His studies in Physical Geography. Baron Humboldt has contributed more to Physical Geography than any other man now living; and that, not only by his individual efforts, but by the direction and encouragement which he has given to innumerable travellers and naturalists. His career seems to have been more closely modelled upon that of De Saussure than of any other of his contemporaries or predecessors. Those branches of Physical Geography which admit of numerical treatment seem most congenial to him; and he has left more of the impress of his personal influence upon the sciences of Meteor-

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[1] Edinburgh Transactions, vol. xiii.

[2] M. Arago gives, no doubt, an erroneous impression in stating that the westerly movement of the line of No Declination has carried it in 200 years from Paris to Philadelphia. Yet I cannot subscribe to the opinion of his able commentator that the Loop of No Declination which passed over Europe in the seventeenth century moved eastwards, and may still be traced in Asia —(British Association, *Fifth Report*, p. 63; Arago's *Meteorological Essays*, translated, p. 330). I conceive that, as stated in the text, the loop moved south-westwards, became successively an oval and a singular point, and was finally worked out previously to 1700.

[3] In September 1841 a remarkable simultaneous disturbance took place in Canada, Scotland, the Cape of Good Hope, and New South Wales. Such occurrences are now known to be very common.

Baron Humboldt on Meteorology—Isothermal Lines.

Magnetism.

ology and Magnetism than upon any others which he cultivated. His conception of *Isothermal Lines* and his treatment of the subject of Climatology in his remarkable paper of 1817[1] gave a new impulse to the former subject. His magnetical observations in his voyage to the Equator have already been adverted to. Besides this we are indebted to Baron Humboldt for directing attention to the simultaneous and seemingly accidental disturbances of the magnetic needle which take place over vast portions of the area of the globe. He commenced observations on this subject in conjunction with M. Oltmanns as early as 1806; and during his residence in Paris he no doubt encouraged his friend Arago in those elaborate observations on the hourly variations of the needle which, to the irreparable loss of science, remained unpublished whilst they might have been most useful.[2] In 1829 simultaneous observations were made in Germany and Russia, and compared by MM. de Humboldt, Dove, and others, with interesting results.[3] It is probable that the results then obtained instigated Gauss to the enlarged enquiry to which I shall immediately refer. M. de Humboldt had already addressed the Russian Government on the same subject, suggesting the registration of hourly observations in their vast territories; and these, the first systematic observations of the kind, have been continued ever since. The suggestion of "Term Days" of *continuous* registration of the Declination Needle was also due to Baron Humboldt. In 1836 he addressed the President of the Royal Society of London on the same subject, and his letter formed the basis of the extensive undertakings which have formed the contribution of the British Government to this great enquiry.

(895.) Baron Humboldt still lives at Berlin, enjoying the respect of all who know him, and the distinguished favour of his Sovereign.

(896.) Gauss.

Carl Friedrich Gauss, late Professor of Astronomy at Göttingen, belonged to that group of celebrated geometers who illustrated the commencement of this century, and of which he was for some years the last survivor; but he too has now passed away.

(897.) His early history and mathematical works.

Gauss was born at Brunswick on the 30th April 1777, of humble parents, and was indebted for a liberal education to the notice which his talents procured him from the reigning duke. His earliest original researches were in the theory of numbers. His *Disquisitiones Arithmeticæ* were published in 1801, and were as profound and original as they have always been considered obscure even by those devoted to such studies. Gauss demonstrated the possibility of geometrically inscribing a regular polygon of 17 sides within a circle; the only extension of geometry in this direction since the time of Euclid. His *Theoria Motûs Corporum Cœlestium*, published in 1809, is a very remarkable treatise on the *geometrical* theory of the planetary orbits; in which it was shown for the first time how the elliptic elements of a heavenly body may be deduced from three observations only of longitude and latitude,—an important extension of Newton's celebrated demonstration in the case of parabolic cometary orbits. In the same work the method of *least squares* (85) was fully unfolded in its applications to astronomy.

(898.) Researches on terrestrial magnetism.

Magnetic force in absolute measure.

These and many other important labours all connected with the higher mathematics, had obtained for Gauss an exalted place among the men of science of his time, long before he commenced those researches on Terrestrial Magnetism, in virtue of which his name is introduced into the present section. It can hardly be doubted, however, that by these—scarcely begun before he had entered on his 55th year—he will be hereafter chiefly remembered. His first work on the theory of magnetism[4] was published in 1833, and excited very general notice, as it contained a remarkable application of the Theory of Attractions to the distribution of magnetism in a steel bar, a singularly ingenious and rigorous proof of the primary law of the magnetic force, and likewise a new and practical application of a suggestion thrown out by Poisson, of a method by which the magnetic directive force of the earth itself may be expressed in absolute measure, irrespectively of the constancy of the magnetism in the bar which is in the first instance used to estimate it. For this purpose two kinds of observation are required,—1st, By vibrating a needle or bar of known weight and dimensions, and observing the time of its oscillation, the force pulling it into the meridian is ascertained in terms of the ordinary dynamical units. The time depends jointly on the magnetic force of the earth, and on that of the bar, or it varies inversely as the *product* of the two. 2dly, Another bar, B, is suspended like the first, A, in the magnetic meridian. A is then brought to act upon B, so as to draw it permanently out of the meridian. The position in which B rests determines the *ratio* of the magnetic force of the earth and of the bar A. But quantities whose *product* and whose *ratio* are given in known measures, are also known; whence the separate intensities of the earth's and the bar's magnetism may be eliminated.[5]

(899.) New magnetical instruments.

Having thus fairly entered on a career of magnetic experiments, Gauss proceeded, in conjunction with an experienced physicist of Göttingen, Professor Wilhelm Weber (420), to invent new apparatus for observing the earth's magnetism and its changes. The instruments devised by them were a Declination Instrument and a Bifilar Magnetometer. The first is a heavy magnetized bar some feet in length, suspended by a bundle of parallel silk fibres. It is suffered to place itself in the magnetic meridian, and the small displacements due to hourly, annual, or irregular fluctuation, are ascertained by viewing with a telescope the reflection of a fixed scale of equal parts placed at some distance in a small mirror which is attached to the magnetic bar. The bifilar instrument is for ascertaining changes of intensity in the earth's magnetism. It is a bar like the last, suspended by two parallel threads or wires. By twisting round the points of double suspension, the bar is forced by torsion into a position at right angles to the magnetic meridian, where it is held in equilibrium by the force of the earth's magnetism, and that of the torsion of the wires. Supposing the latter force to be constant, if the former vary, the bar will change its position, which is observed by the mirror and telescope as before.

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[1] Memoires d'Arceuil, tom. iii., p. 462.

[2] Posthumously published in his *Œuvres*.

[3] See abstract in *Bibliotheque Universelle*, Août 1832.

[4] *Intensitas vis magneticæ terrestris ad mensuram absolutam revocata.* Gott. 1833.

[5] The *unit of force* to which these intensities are referred is that force (in grains) which acting on unit of mass through unit of time (a second) generates in it unit of velocity (a foot).

(900.) To these instruments, Professor Lloyd, of Dublin, added another for measuring the vertical component of the magnetic intensity. It is a magnet suspended horizontally on knife-edges like those of a balance. Its deflection from the horizontal line indicates variations in the vertical portion of the earth's magnetism.

(901.) The dip is determined in the usual way; the *variations* of dip, however, are ascertained by comparing the variations of horizontal and vertical intensity.

(902.) The Göttingen magnetical observations.

Gauss did not content himself with suggesting new forms of apparatus, and recommending them to others. With the active assistance of M. Weber, he erected, in 1833, at Göttingen, a magnetic observatory free from iron (as M. de Humboldt and Arago had already done on a smaller scale), where he watched with patience the incessant movements of the newly-constructed needles or bars. It was from the same observatory that he sent telegraphic signals to the neighbouring town, thus showing the practicability of an electro-magnetic telegraph (856). He farther instituted an association (*magnetischer Verein*), composed at first almost entirely of Germans, whose continuous observations on fixed Term-days extended from Holland to Sicily.[1] The marvellous coincidence of the occurrence of even the minute irregularities of the earth's magnetism was thus more fully established.

(903.) Gauss's mathematical theory of terrestrial magnetism.

The Mathematical Theory of Terrestrial Magnetism of Gauss[2] is intended to replace all arbitrary assumptions whatever as to the distribution of magnetism in or over the earth. It proposes to express by an empirical law, involving as little of hypothesis as possible, the direction of the freely suspended magnetic needle and its directive force at any point of the earth's surface, the data being of course derived from a limited number of observations.

The theoretical assumption with which Gauss starts is merely this,—that the elementary force of magnetism varies inversely as the square of the distance, and that it is distributed over the matter of the terrestrial globe in a way or according to a law presumed to be entirely unknown. (904.)

(905.) Theorems concerning attractions.

Following up the methods employed by Laplace and others, for representing the attractions of a sphere or spheroid, he proposes to discover the form of that remarkable function (sometimes called the *Potential*)[3] whose differential coefficients express the resolved components of the total magnetic force. This quantity V, and also its differential coefficients (representing the attractions in given directions), may always be expressed by a series with indeterminate coefficients, which is known to converge more or less rapidly; and since the component forces or attractions are given by observation, the coefficients of the terms of the series representing them may be deduced from a comparison with the data. The convergency is greatest if the magnetic matter be disposed towards the centre of the sphere, least if it reside near its surface.

Retaining quantities of the fourth order, there are twenty-four constants, which, rigorously speaking, may be deduced from complete observations of the three magnetic elements (888) at only eight stations anywhere situated on the surface of the globe. With great patience and skill, Gauss collected as many available data as possible for determining these constants with accuracy, and he thence deduced by calculation the values of V, those of the declination, horizontal and vertical force, and that of the dip for all points of the globe. The beautiful charts which he caused to be constructed show a remarkable general accordance with the complex facts of magnetism as then known. But in many instances more accurate data have since been obtained applicable to the improvement of the empirical theory. Perhaps the most surprising fact which Gauss considers to be demonstrated is this, that the average amount of magnetic force associated with *every cubic yard* of the earth's volume (supposing the distribution uniform) is equal to that contained in six saturated steel bars each a pound in weight. (906.)

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[1] The volumes of their publications, from 1836 to 1839, contain much interesting information on the history of this subject.

[2] *Allgemeine Theorie des Erdmagnetismus.* Leipzig, 1839.

[3] See Art. 877. This function V represents the integral $\int\frac{dm}{\rho}$, were dm is the attracting or repelling element, and ρ its distance from the point acted on. Gauss represents in his charts the values of the function V at different points of the earth's surface. The lines of equal values of V are everywhere perpendicular to the direction of the needle, and the *horizontal* intensity is inversely as the distance between two adjacent lines.

(907.) Great merit of Gauss. His death.

On the whole, it is no small praise to say that the great geometer of Göttingen occupies the same rank in the theoretical science of terrestrial magnetism as Kepler did in the theory of astronomy. That a person devoted for the greater part of his life to pursuits connected with the most abstract geometry, should have at last thrown himself with so much zeal into the practical solution of a complicated experimental problem, is a circumstance as rare as it is praiseworthy. Gauss lived long enough to see his methods adopted all over the world, and his name honoured amongst every civilized people. Gauss died at Göttingen (where he had resided since 1807), in great tranquillity, on the 23d February 1855, in the 78th year of his age.

(908.) Importance of national expeditions.

But to obtain the data of the empirical theory with exactness, it is evident that expeditions fitted out expressly with accurate apparatus, and directed at once to many points of the habitable globe, are indispensable. Powerful governments can alone effect this; and to Baron Humboldt is due (as has been shown) the praise of having vigorously pressed the importance of these upon the governments of England and of Russia. The vast marine resources of the former, and the peculiar magnetic interest of the stupendous Asiatic territory of the latter, rendered their cooperation highly important. In the result, Great Britain has accomplished by far the larger share of this vast enterprise.

(909.) General Sabine.

To Major-General **Edward Sabine**, of the Royal Artillery, is mainly due the judicious management of these magnetic explorations, and the speedy and skilful publication of their interesting results. During the course of an active life he has enjoyed opportunities of making extensive observations with magnetic apparatus and with the pendulum (238) throughout a great range of latitude. His experiments (carried on principally between the years 1819 and 1826) were made in Brazil, the coast of Guinea, Spitzbergen, and Arctic America. His observations on magnetic intensity are particularly valuable, and first indicated the position of a region of maximum intensity in North America considerably to the south of the magnetic pole as indicated by the dipping needle. To him we also owe a valuable Intensity Chart of the Globe, and a Magnetic Survey of the British Islands, published in the reports of the British Association for 1836 and the two following years.

(910.) British magnetical expeditions. Captain Sir J. C. Ross.

But his efforts in promoting and directing the system of national magnetical research set on foot at Baron Humboldt's instigation are of still greater importance, to which, in its earlier stages, the exertions of Dr Lloyd (550) were also of essential service. Although seconded by young, able, and enthusiastic officers of the service to which General Sabine belongs, the difficulty of starting simultaneously systematic observations (with instruments new and little understood, and dispersed to the widest possible extent over the surface of the globe), was evidently very great. Canada, St Helena, the Cape of Good Hope, and Van Diemen's Land, were selected for primary stations; and the vastly voluminous results of hourly or two-hourly observations of numerous instruments continued year by year came pouring in to the central establishment at Woolwich under General Sabine's presidency. Besides these, several nautical expeditions were fitted out for similar purposes, the most important of which was sent in 1840 under the direction of Sir James Clark Ross to approach as nearly as might be to the Antarctic Pole. This voyage, whether in respect of the spirit of adventure displayed, the wonderful character of the natural objects revealed by it for the first time to human view, or the importance of the scientific results obtained, may rank with any of our memorable polar expeditions. By the aid of an ingenious instrument contrived by Mr Fox, trustworthy magnetical observations were made on dip and intensity (as well as on declination) even in the open sea, and thus the area contributing to our knowledge of the earth's magnetism was vastly increased. The results of these researches properly reduced have been gradually laid before the world by General Sabine in a series of memoirs of the utmost interest, contained in the *Philosophical Transactions* from 1840 to the present time.

(911.) Geographical results—curves of intensity.

With regard to the geographical phenomena of magnetism, it may now be inferred almost with certainty that the position of the Antarctic magnetic pole is in a region hitherto inaccessible, and to the south of New Holland, placed somewhere near longitude 150° E., and probably not within 17° of the pole of the earth, a latitude which was reached by Sir James Ross in a longitude somewhat farther east.[1] It appears also that in the southern as in the northern hemisphere there are two centres of greatest intensity, round which the curves of equal intensity form ovals, and afterwards loops like lemniscates. The stronger magnetic centres of each hemisphere are *near*, though apparently not coincident with, the two proper magnetic poles. The following numbers approximately represent on a scale of *absolute* intensity (898), in which the grain, the foot, and the second are units, the magnetic force at the four centres just mentioned; the second column contains the corresponding values on Baron Humboldt's scale, mentioned in Art. 885.

	Absolute.		On Humboldt's Scale.
In North America, . . .	14·2	...	1·88
In Siberia, ...	13·3	...	1·76
South from New Holland, .	15·14	...	2·00
The other Antarctic centre,	14·9	...	1·97

The absolute intensity at St Helena, which is not far from the minimum, is 6·4. These observations also fully confirm the progressive motion of the whole system of magnetic lines on the surface of the globe.

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[1] See General Sabine's Charts in *Phil. Trans.*, 1844.

(912.) European magnetical observatories. In Europe national, and even private, observatories have contributed largely to our knowledge of the laws of magnetism. Among these observatories may be mentioned Greenwich, Dublin, Makerstoun in Scotland, Munich, Prague, Brussels, St Petersburg, and the numerous other Russian stations. At Greenwich and at Kew, near London, the *automatic* registration of magnetical and meteorological instruments, by means of photography, was introduced by Mr Brooke and Mr Ronalds. It would be impossible in this place to give even a summary of the results obtained from these and the Colonial establishments. Besides the valuable deductions by General Sabine already referred to (910), the careful analysis of the formal laws of magnetism obtained at their respective observatories by M. Lamont, M. Kreil, and Mr Broun (Sir Thomas M. Brisbane's observer), merit special notice.

(913.) Dependence of magnetic periods on the sun and moon. The primary cause of the earth's magnetism remains involved in the greatest doubt. That it is due to electric currents, and not to permanent magnetism, is at least probable; and it is likely that these currents may, in part at least, be of a thermo-electric character, or the effects may possibly depend upon the direct demagnetising influence of temperature, as Dr Faraday supposes (830). The secular magnetic changes will probably ever remain the most unaccountable. The greater portion of those which are obviously periodic seem to depend upon the position and efficiency of the sun in its apparent diurnal and annual course, having their crises at certain hours of the day, and certain seasons of the year. It is understood that the most recent researches leave little doubt as to a like influence arising from the moon's position.[1] It appears also to be indicated (although the induction is perhaps yet incomplete) that the diurnal changes, and also those of a capricious and irregular character (magnetic storms), have a period of greatest and least intensity of fluctuation extending to about ten years, a minimum having occurred in 1843, and a maximum in 1848. This nearly coincides with a period of greatest and least abundance of the solar spots detected by M. Schwabe, and it is possible that there is a real connection between the phenomena. The first recognition of a ten-year magnetic period appears to be due to M. Lamont, that of a probable concurrence with the frequency of solar spots to General Sabine.

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[1] While correcting the press of this page, I have received an interesting paper by General Sabine (*Phil. Trans.*, 1856), in which the dependence of the various magnetic elements on the moon's diurnal place is deduced from a very large number of observations. The change of declination in the course of the *lunar day* amounts to above 38″.

Addition to Art. 283, *page* 860.

The following is a continuation of the list previously given of the small Planets:—

No.	Name.	Date of Discovery.	Discoverers.
36	Atalanta	1855 Oct. 5	Goldschmidt.
37	Fides	Oct. 5	Luther.
38	Leda	1856 Jan. 12	Chacornac.
39	Lætitia	Feb. 8	Chacornac.
40	Harmonia	March 31	Goldschmidt.
41	Daphne	May 22	Goldschmidt.
42	Isis	May 28	Pogson.

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